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Some factors affecting agricultural land use change in southern Ontario, 1971-1976.

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SOME FACTORS AFFECTING AGRICULTURAL LAND-USE CHANGE IN SOUTHERN ONTARIO, 1971 - 1976

by

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ABSTRACT

The farmlands of Southern Ontario have decreased significantly and monotonically during the last 25 years. Growth of population, which required rapid urban expansion led to the loss of agricultural land uses. Such a change was greatest closest to the metropolitan cities and on poor soils. Townships remote from the metropolitan areas and with good soils had experienced an increase or minimum decrease of agricultural land. Growth of population, soil quality, and proximity to the metropolitan cities have been among the principal determinants of change in agricultural land uses in Southern Ontario.

To

My parents, Mr.Mazedur Rahman
and Mrs. Saleha Khatun

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CHAPTER ONE

Introduction:

Increasing demand for limited land resources and competition among land uses are causing land use changes observable in the context of both time and space (Barlowe, 1972: p. 86). In this competition valuable agricultural land is being displaced by non-agricultural land uses (Zeimetz et al, 1976; p. 1).

North America, in particular, has experienced a rapid decline of agricultural lands. The continuous increase of urban population and simultaneous growth and spread of urban centres have led to a reduction of agricultural land resources (Bogue, 1956: p. 19, Griffin and Chatham, 1958: p. 205). A notable relationship exists between the loss of farmland and the increase of urban and rural non-farm population (Bogue, 1956: p. 20). Spatially, the decline of farmland is greatest closest to the metropolitan cities and decreases with increasing distance from them (Crerar, 1961: p. 186). Moreover, most of the urban centres expand onto areas of good quality soils (Pearson, 1972: p. 10, Ward, 1977: p.74). Hart (1968: p. 438) demonstrated a significant correlation between soil capability classes and loss of farmlands.

In Southern Ontario, the rapid growth of urban population requires an expansion of urbanized space (Krueger, 1977: p. 119). Increasing demand for urban space leads to the conversion of agricultural land into urban uses. Gertler and Smith (1961: p. 175) estimated that for every acre of land actually used for urban development at least another two acres are 'sterilized' for agricultural uses. In Southern Ontario, between 1951 and 1976, the total farm area had decreased by 19 percent, cropland and summer fallow by 1.3 percent, and improved pasture by 27 percent. Such an alarming decrease of farmland should challenge geographers to study the problem in detail. Wise planning for Canada's agricultural future cannot proceed without a solid understanding of the spatial and temporal dynamics of agricultural land use changes, and the factors influencing them.

Essentially, this study is concerned with the analysis of temporal and spatial changes in total farm area, cropland and summer fallow, and improved pasture in Southern Ontario. First, trends will be analysed by counties for a 25 year period from 1951-1976. Secondly, the relationship between changes in the last five year period (1971-1976), and the increase of total population, the proportional distribution of good, medium, poor and organic soils, and the distance of the land from the nearest metropolitan city (population over 100,000) will be investigated at the township level. Such a study should be of some help to Ontario policy makers in better understanding the problem of declining agricultural land.

Study Area:

Southern Ontario, in this study, comprises all counties south of Haliburton, Muskoka, and Nipissing (Fig. 1). It contains five natural divisions: (i) the broad half-dome that slopes from the Niagara Escarpment to Lake Erie and Huron, (ii) the Niagara Escarpment itself, (iii) the lowland between the St. Lawrence and Ottawa River, (iv) the South-Central Ontario between the edge of Canadian Shield, and (v) the Canadian Shield (Chapman and Putnam, 1966: p. 172). Southern Ontario was chosen for three reasons: (i) the region contains some of the best agricultural land in Canada, contributing about 35 percent of the total value of agricultural production (1976), (ii) during the last two decades the region has been experiencing rapid industrialization and urbanization, and losing agricultural land to urban uses, and (iii) Ontario's most productive foodland is located in the same area as the greatest concentration of population, resulting in the most severe land use conflicts (O.I.A., 1975: p. 14).

Objectives of the Study:

The purpose of this study is to analyse the temporal and spatial dynamics of agricultural land use change in Southern Ontario. Changes in total farm area, cropland and summer fallow, and improved pasture will be related to change in total population, proportions of the total land under good, medium, poor and organic

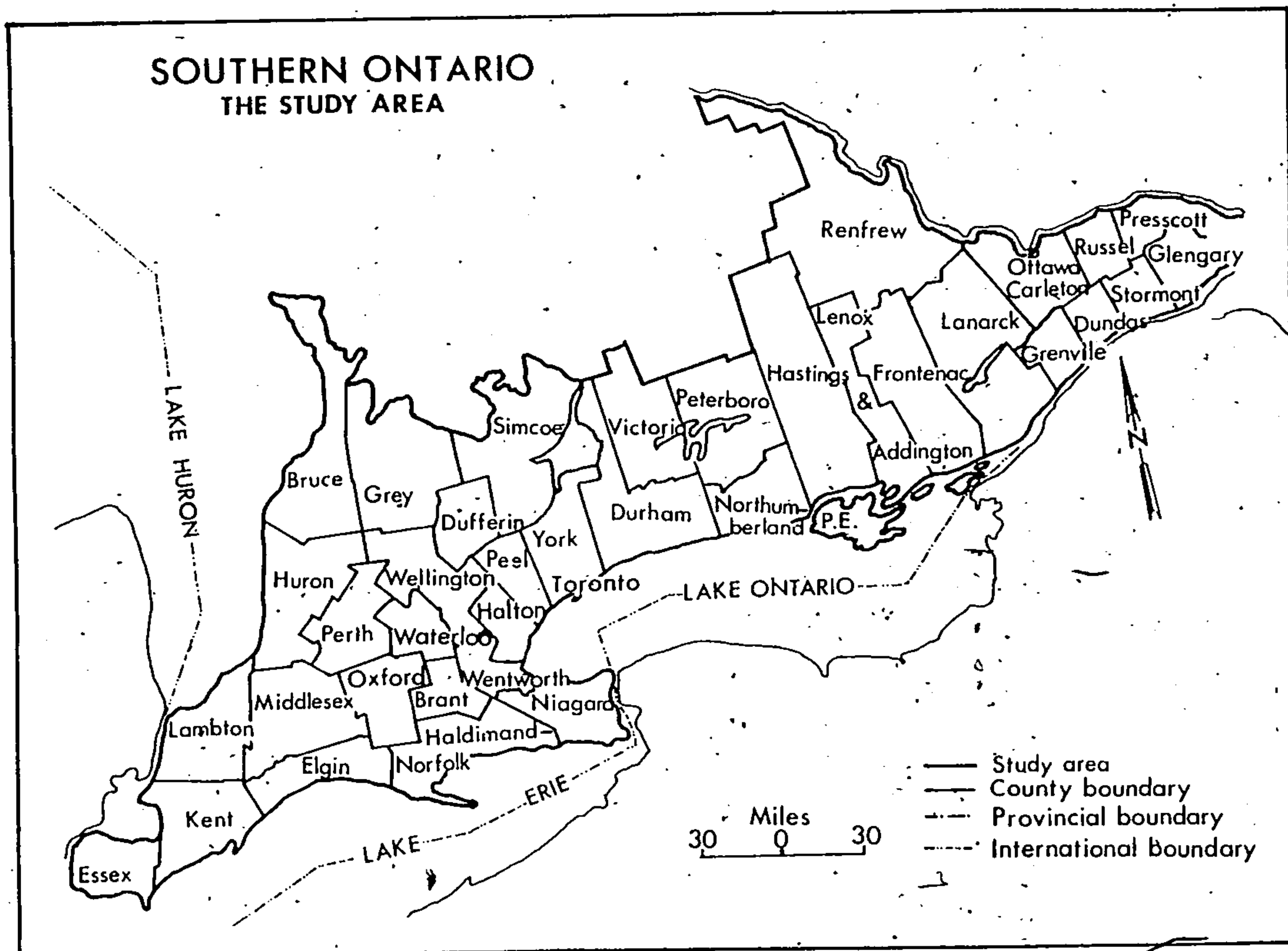
SOUTHERN ONTARIO
THE STUDY AREA
LAKE HURON
LAKE ONTARIO
LAKE ERIE
Renfrew
Presscott
Russel
Glengary
Ottawa Carleton
Stormont
Dundas
Grenville
Lanarck
Lenox
Frontenac
Hastings
&
Addington
Peterboro
Victoria
Simcoe
Durham
Northumberland
P.E.
Bruce
Grey
Dufferin
York
Peel
Toronto
Huron
Wellington
Halton
Perth
Waterloo
Oxford
Wentworth
Middlesex
Brant
Niagara
Lambton
Haldimand
Elgin
Norfolk
Kent
Essex
N
Study area
County boundary
Provincial boundary
International boundary
Miles
30 0 30

Fig. 1

soil, and the distance of the land from the nearest metropolitan cities (population over 100,000 persons).

The last 25 years witnessed a rapid growth of urban centres and population and a reciprocal loss of farmland. In order to gauge the general magnitude of this change, the first step will be to analyse the trends of farmland changes for Southern Ontario at the county level for the last 25 years (1951-1976). Patterns will be established and tested for their consistency.

In order to attain the second objective of the study -- a measurement of the relationships between land use changes, population growth, soil capabilities and distance factors, a detailed analysis will be conducted using the data at the township level. Availability of data will confine this study to the period 1971-1976.

The second objective of the study will entail five steps. First, the percentage change in total farm area, cropland and summer fallow and improved pasture, and the percentage change in total population in each township during the period 1971-1976 will be calculated. Second, the percentage composition of good, medium, poor and organic soil in each township will be calculated. Third, the distance of each township from its nearest metropolitan city's built-up area will be measured. Fourth, the spatial pattern and autocorrelation function in the change of total farm area, cropland and summer fallow and improved pasture will be analysed. Fifth, the interrelationship between the variables will be studied.

Review of Literature:

The relevant literature on agricultural land use change may be divided into two basic categories. The first category and by far the most extensive, is concerned with the topic of agricultural land use change in general. It includes reviews of recent works done on the nature and causes of agricultural land use changes in different regions of the world. The second category is concerned with agricultural land use change in Southern Ontario and deals with specific studies, existing models and methods.

(a) General Considerations of Agricultural Land Use Change

Bogue (1956: p. 19) in his land use study of metropolitan areas felt that much of the agricultural lands were changing into urban uses. Bogue's statement .... "the spreading of cities is an unmistakable drain upon agricultural resources" was later echoed by Gregor (1957: p. 311). Gregor in his study on California has shown that agricultural lands were being absorbed by adjacent growing urban centres. He indicated that with the rapid growth of population, there was a corresponding decline in crop acreage, and much of the lands of Santa Clara Valley have been taken over by urban uses. Gregor's study has suggested the nature and cause of agricultural land use change in recent year; and the concept has also been explained by Griffin and Chatham (1958).

Griffin and Chatham (1958: p. 195), in their study of Santa Clara county, demonstrated that... 'Urban and industrial expansion voraciously consumes what was once an agricultural heartland of Santa Clara valley of California.' The authors have shown that agricultural lands were declining with the increase in urban and rural non-farm population. Griffin and Chatham's study assumed that most of the urban and industrial expansion has taken place on the best quality soil; thus the loss of good, plain (flat) and highly accessible soils led to the decline of agricultural lands.

Sinclair (1967: p. 72-87) postulated that much agricultural land is withdrawn from farming in the urban-rural fringe for speculation and may, in fact, remain idle for many years. Gertler and Hind-Smith (1961: p. 175) as well as Sinclair emphasized this 'sterilization' of agricultural land by urban growth. Hart (1968: p. 417-440) in his study of Eastern United States showed that population growth and the spread of cities was but one of many factors that caused the 'loss and abandonment' of agricultural land. He concluded 'that physical hindrances to effective agriculture (such as poor agricultural land capability) have been the most important factors influencing the loss and abandonment of cleared farmland'. Hart assumed that besides population growth, soil capability might show a higher degree of statistical correlations with farmland change.

Besides population growth and soil quality, agricultural land use has always been influenced by location. The distance from an urban market has a direct bearing on transport cost, economic rent and land value, and thus it controls agricultural land use change (Von Thunen 1826, Dunn 1954, Alonso, 1964).

Emphasizing the significance of distance of farmland from the market centres, Von Thunen explained how the distance from the market centres regulates agricultural land uses. While commenting on Von Thunen's idea, Grotewold (1959: p. 346-355) concluded that with the development of transport networks, the effect of transport cost on economic rent may be minimized, but the initial effect of distance on land use changes remains the same. Grotewold's idea was later reflected in Crerar's study.

Crerar (1961, p. 186), in his study on the metropolitan regions of Canada, demonstrated that the loss of farmland is greatest closest to the metropolitan cities, and decreases with the increase in distance from them.

Besides all the above mentioned factors affecting agricultural land use changes, government policies and legislation and technological changes may also influence agricultural land use change (Gaffney, 1964: p. 11).

There has been a marked increase of interest in agricultural land use change. Most recent studies are concerned with the temporal and spatial change and their causes and consequences. These studies are useful for suggesting methodologies to study agricultural land use changes.

Bhatia (1970: p. 226) in his study of Uttar Pradesh, India, felt that agricultural land generally and cropland specifically are changing continuously over time. Such temporal changes can be measured by linear and curvi linear trend analysis, an appropriate technique in determining the rate of change in a short time series. Bhatia considered only the rate of change and not the cause of such change. Yet the rate of change should be related to its causal factors in order that concrete inferences may be made.

Recent methods of analysing the changes in agricultural land uses include the comparison of aerial photographs and their interpretation.

Austin (1965) in his study of the United States, compared air photographs of two time periods to explore the change in land uses and to delimit the land use regions.

Zeimetz et al (1976: p. 2) in their study of fifty-three fast growing counties of the United States compared the air photographs of 1961 and 1970 to calculate the quantity of agricultural land lost and converted into urban uses. Land use changes were related to population increase and expressed as the cropland urbanized coefficient C thus:

$$C = \frac{\Delta c}{\Delta t} \Big/ \frac{\Delta p}{\Delta t}$$

where c represents the number of acres converted from cropland to urban use, p and t represent population and time factors respectively.

Comparison of aerial photographs and their statistical interpretations have been regarded as a modern and widely accepted technique. Krueger (1959), Martin (1975), and Zierman (1977) have used this method in their study of land use change in different parts of Southern Ontario.

(a) Agricultural Land Use Change in Southern Ontario:

Empirical studies of agricultural land use changes in Southern Ontario are very few. Studies done by Krueger (1959, 1970, 1977, 1978), Putnam (1962), Girt (1975), Matthews (1956), Louth Township Report (1957), and Crerar (1961) are very important as they identified the problem of agricultural land use change and their causes in this region.

Krueger (1959: p. 40-140) studied the land use change in the Niagara fruit belt. He showed that tender fruit soils that supported orchards and vineyards were being absorbed by urban settlements, roads, and business centres. His subsequent studies (1970: p. 134-149, 1977: p. 119, 1978: p. 179-194) of this region substantiated the same continuing trends.

Putnam (1962: p. 60-68) felt that declining agricultural land uses in central Lake Ontario plain were due to urban expansion and rapid development of industrial complexes. The significant decrease in total farm acreage that he observed between 1931-1956, he attributed to the 'response to changing economic conditions created by the rapid growth of the adjacent urban areas'.

Girt (1975: p. 16-20) attempted to study the temporal and spatial dynamics of agricultural land use change in Southern Ontario. He assumed that agricultural lands of Southern Ontario townships were changing during the period between 1951-1966 with the increase of population. Using Markov Chain process, Girt established two models of agricultural land use change in this region. The two models were:

(a) Model I: This model was time-dependent and assumed that the 'change in the proportion of each township's area in census farms is a function of the state currently occupied and the time spent in that state', i.e. the First Order Markov process.

(b) Model II: This model was both time and population dependent and assumed that a change in agricultural land use was related to population change as well as time.

Although Girt's study is significant for its attempt to relate process to causes in a quantitative way, it did not measure: (i) the spatial trend of agricultural land use change, and (ii) the relationship between farmland change and the proportion of soil capability classes in the area.

Matthews (1956: p. 55), in his study of soil resources and land use hazards in Southern Ontario demonstrated that soil capability classes, (which were based on topography, drainage, fertility, moisture holding capacity, water erosion, and stoniness) influenced the agricultural land use pattern as well as land productivity. Matthews's study was more generalized and lacked any statistical measurement of the relationship between the land use change and soil capability classes.

Crerar (1961: p. 1) identified the impact of distance from urban centres on agricultural land use. Considering the metropolitan areas in Southern Ontario with population of over 100,000, he found that townships closest to those metropolitan areas experienced a rapid decline of agricultural land , whereas townships located far away from them either experienced no change or gained in farmland.

The three factors responsible for the decrease of agricultural land as evident from the literature, were: the increase of population (patricularly urban and rural non-farm population), proportional distribution of soil capability classes, and distance of the land from the urban centres. Government policies, programs and legislation also influence the change in agricultural land uses. The few studies on Southern Ontario suggested that the trend of change in agricultural land uses and their causes were similar to those encountered elsewhere in the world. Moreover, they lacked temporal and spatial analysis of agricultural land use change and did not consider simultaneously the three main causes of such changes in Southern Ontario. This study, it is hoped, would fill a gap in the literature on the trends and causes of change of agricultural land use in Southern Ontario.

The Model:

From the review of studies done by Krueger (1959, 1970, 1977, 1978), Hart (1967), Matthews (1956), and Crerar (1961), it is evident that agricultural land use change is dependent upon the growth of population, proportional distribution of soil capability classes, and distance from urban centres. To represent the composite relationship between those factors and land use change, a model of agricultural land use changes is proposed.

Growth of population would represent one of the inputs, soil capability classes and distance from urban centres would constitute the status variables while economic conditions, government policies, program and legislation would be the filters for land use choice, and land use changes would represent the output in the model.

In the proposed model of agricultural land use changes in Southern Ontario (Fig. 2), the changes in agricultural land uses would be due to competition between urban, non-farm uses and farm uses, i.e. competition for foodland and housing spaces. The main reason for such a competition of land uses is the growth of population which increases the need for land uses for food production, housing, industry, transport and recreational purposes. The basis of competition are: (i) land value, and (ii) economic rent achieved from the land. The principal determinants of land value are: (i) population pressure and demand for land, (ii) quality of the land in terms of its soil fertility, and (iii) distance of the land from market centres. On the other hand, economic rent is determined by: (i) production capability of soil (Ricardo, 1911: p. 34), (ii) distance of the land from market (Von Thünen, 1826, Hoover, 1937: p. 30, Lösch, 1954: p.41, Dunn, 1954, p.9, Isard, 1956, p.195), and (iii) type of land use, which also includes perishability and bulkiness of production, when the land is used for agriculture (Von Thünen 1826). Sometimes, the retirement of an individual farmer who would prefer to sell his farmland at a high price inevitably to a developer for urban uses also leads to land use change (Krueger, 1977: p. 119). According to the proposed model, therefore, land use changes in keeping with: (i) the need for land uses expressed in terms of population growth, (ii) proportional distribution

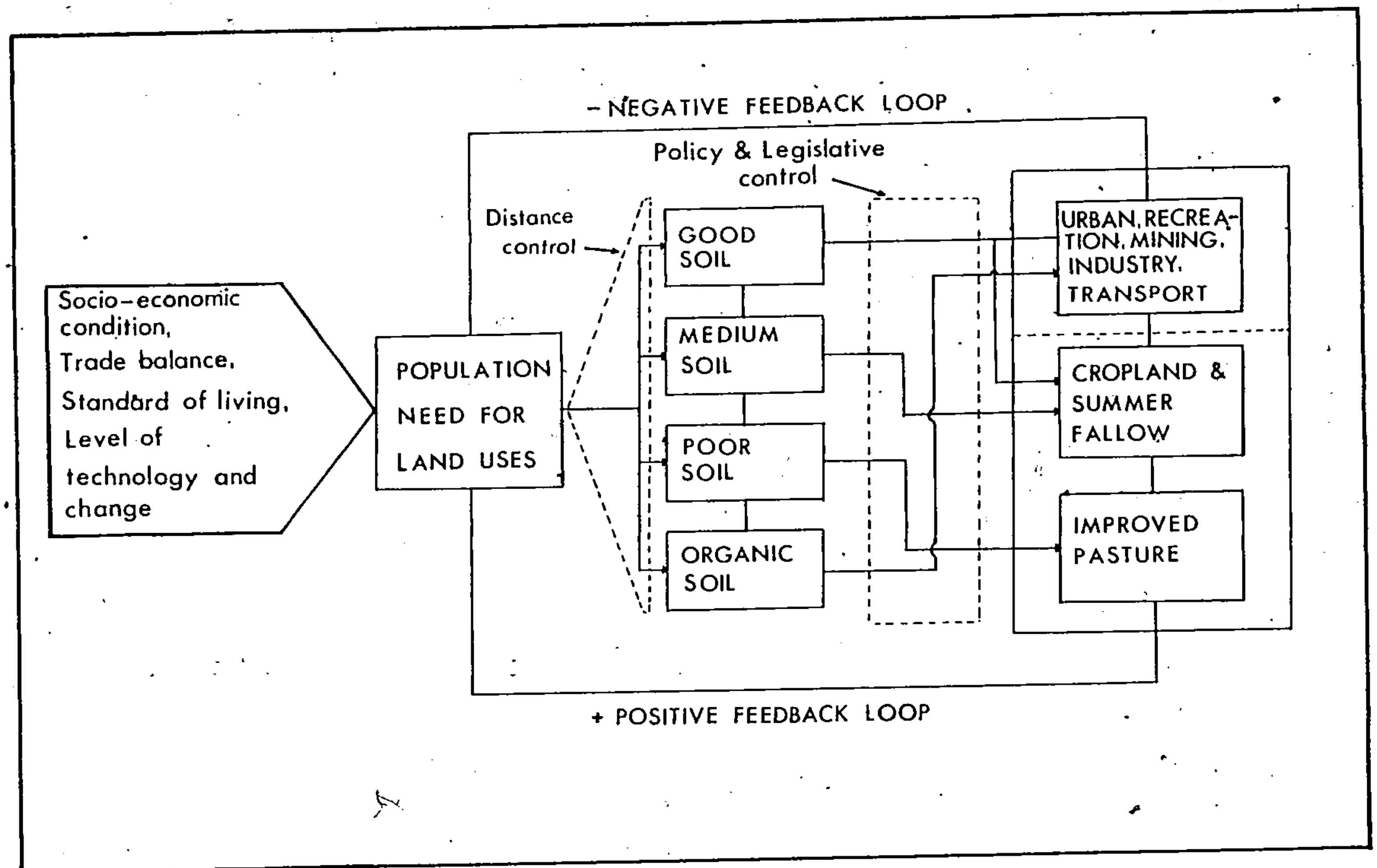

Fig. 2 Model of Agricultural Land Use Change in Southern Ontario.

of good, medium, poor and organic soil capability classes, and (iii) distance of the land from the nearest metropolitan area.

In the proposed model, food supply and urban space may be considered as links in the positive feedback loops. Growth of population would lead to an increased demand for food supply and urban space. The increased demand of food supply would lead to the intensification of agriculture and an increase of farmland (Gaffney, 1964: p. 11). The increase of farmland would then result in an increase of food supply which in turn would encourage further increment of population. Similarly, the growth of population would require more employment, services and housing space and lead to the increase of land used for industry, transport, commerce and housing. The attainment of sufficient urban space would encourage further population growth. These are the two positive feedback loops in the model, assuming that the land availability for food production and urban needs could be obtained, without limits, from "vacant" lands used extensively for forestry, recreation, hunting and ranching. In reality, the land available for farm and non-farm uses is constant, and "vacant" land is finite. The increase in total population would demand a simultaneous increase of land for both farming and housing, commerce, industry, transport and recreation - all of which would not only have to face the land availability constraints, but would also have to compete with one another.

In the proposed model, assuming that the availability of total land is constant and "vacant" land is finite, the growth of population would encourage the expansion of urban land uses which, by virtue of their higher economic land rent, would out-compete farmland uses. Decline in farmland would lead to a decline in food supply, unless agriculture is intensified or additional food is imported. The former would necessitate increased energy input in farming. The latter would aggrevate the balance of payments. Both may increase the strain on the economy, lower the standard of living, encourage out-migration and eventually discourage population growth. This is the negative feedback loop in the model, where changes introduced through the socio-economic and technological attributes would tend to keep the model in equilibrium (Garrison and Marble, 1957: p. 137-144).

In the proposed model, assuming constant socio-economic conditions in Southern Ontario, the relationships between population growth, proportional distribution of good, medium, poor, and organic soil capability classes and distance of the land from the metropolitan areas, on the one hand and the changes of total farm area, cropland and summer fallow, and improved pasture on the other, would be as follows:

i) The townships with a high percentage of population increase would experience high percentage decrease of total farm area and cropland and summer fallow.

ii) Townships with high percentage of good soil capability classes and located closest to the metropolitan centres would experience the greatest loss of good soil capability classes, total farm area, cropland and summer fallow because urban expansion has preference for good soils with flat topography, good drainage and accessibility.

iii) However, townships with high percentage of good soil capability classes but located away from metropolitan areas would experience an increase of total farm area, and cropland and summer fallow.

iv) Townships with high percentage increase of total population and located closest to the metropolitan area would experience an increase and intensive use of organic soil suitable for horticulture and market gardening, as the demand for such products would be increased simultaneously with population growth.

v) Townships with high percentage of medium soil capability classes and located away from metropolitan centres would experience an increase of total farm area and cropland and summer fallow, because medium soil capability classes are suitable for cropping and are less preferred for urban and industrial expansion.

vi) Townships closest to metropolitan areas with high percentage of medium soil capability classes may experience a decrease of total farm area, cropland and summer fallow, provided that the capability restrictions do not hinder urban expansion.

vii) Poor soils are suitable for improved pasture, outdoor recreation and silviculture. Townships with a high percentage of poor soil capability classes may experience some increase of improved pasture.

Hypotheses:

In this study, a number of hypotheses were suggested to identify the nature of agricultural land use change, and then to link the temporal and spatial pattern of change to their causes.

First, the temporal trend of land use changes were analyzed by counties. Krueger (1959, 1970, 1977, 1978) found that in his study area agricultural lands were monotonically declining over time. This proposition will be tested here as follows:

H_1: In Southern Ontario, in the last 25 years, total farm area has been monotonically declining.

H_2: In Southern Ontario, in the last 25 years, cropland and summer fallow has been monotonically declining.

H_3: In Southern Ontario, in the last 25 years, improved pasture has been monotonically declining.

Secondly, the spatial pattern of changes in agricultural land uses of Southern Ontario will be analysed by townships. Since the spatial pattern of population growth, distribution of soil capability classes and the location of metropolitan areas are not uniform throughout the region, the spatial pattern of agricultural land use change may not be uniform and may be the subject of spatial autocorrelation. In this study, the spatial pattern of land use changes will be described and the degree of randomness of their distribution and their spatial autocorrelation will be verified. The following hypotheses will be tested for Southern Ontario:

H_4: The spatial pattern of change in total farm area is not random and is subject to spatial autocorrelation.

H_5: The spatial pattern of change in cropland and summer fallow is not random and is subject to spatial autocorrelation.

H_6: The spatial pattern of change in improved pasture is not random and is subject to spatial autocorrelation.

Thirdly, this study aimed to analyse the inter-relationships between the variables studied. Hart (1967), Krueger (1959, 1970, 1977, 1978), Matthews (1956), and Crerar (1961), in their studies of agricultural land use changes, found that the change in agricultural land use was related to the change in total population, proportional distribution of soil capability classes and distance of the land from metropolitan areas. In this study, to analyse these interrelationships, the following hypotheses will be tested for Southern Ontario:

H_7: the percent change in total farm area is a function of:

i) the percent change in total population;
ii) the percent of total land under good soils,
iii) the percent of total land under medium soils,
iv) the percent of total land under poor soils,
v) the percent of total land under organic soils,
vi) the distance of each township from the nearest metropolitan city with population of over 100,000.

H_8: The percent change in cropland and summer fallow is a function of:

i) the percent change in total population,
ii) the percent of total land under good soils,
iii) the percent of total land under medium soils,
iv) the percent of total land under poor soils,
v) the percent of total land under organic soils,
vi) the distance of each township from the nearest metropolitan city with population of over 100,000.

H_9: The percent change in improved pasture is a function of:

i) the percent change in total population,
ii) the percent of total land under good soils,
iii) the percent of total land under medium soils,
iv) the percent of total land under poor soils,

v) the percent of total land under organic soils,

vi) the distance of each township from the nearest metropolitan city with population of over 100,000.

Data Sources:

For this study, the 1951-1976 census periods were chosen. Census data for acreage of total farm area, cropland and summer fallow, and improved pasture at the county level were derived from the published compiled returns to the 1951, 1956, 1961, 1966, 1971, and 1976 Census of Canada, Agriculture, Ontario. Census data for the same variables at the township level were collected from the computer tapes for 1971 and 1976 Census of Canada, Agriculture Ontario. Thirty-nine counties and three hundred and fifty-four townships were used as the areal study units, (Figure 3, Appendix).

The first independent variable, the percentage change of total population, was collected for each of 354 townships using the 1971 and 1976 Census of Canada Population, Ontario, computer tapes. The next four independent variables, the percentage of total land under good, medium, poor and organic soil were collected for each township from A.R.D.A. Report no. 8, 1975. The remaining independent variable, the distance of each township from the nearest metropolitan city (built-up area) with a population of over 100,000 were measured from the Canada, topographical map series.

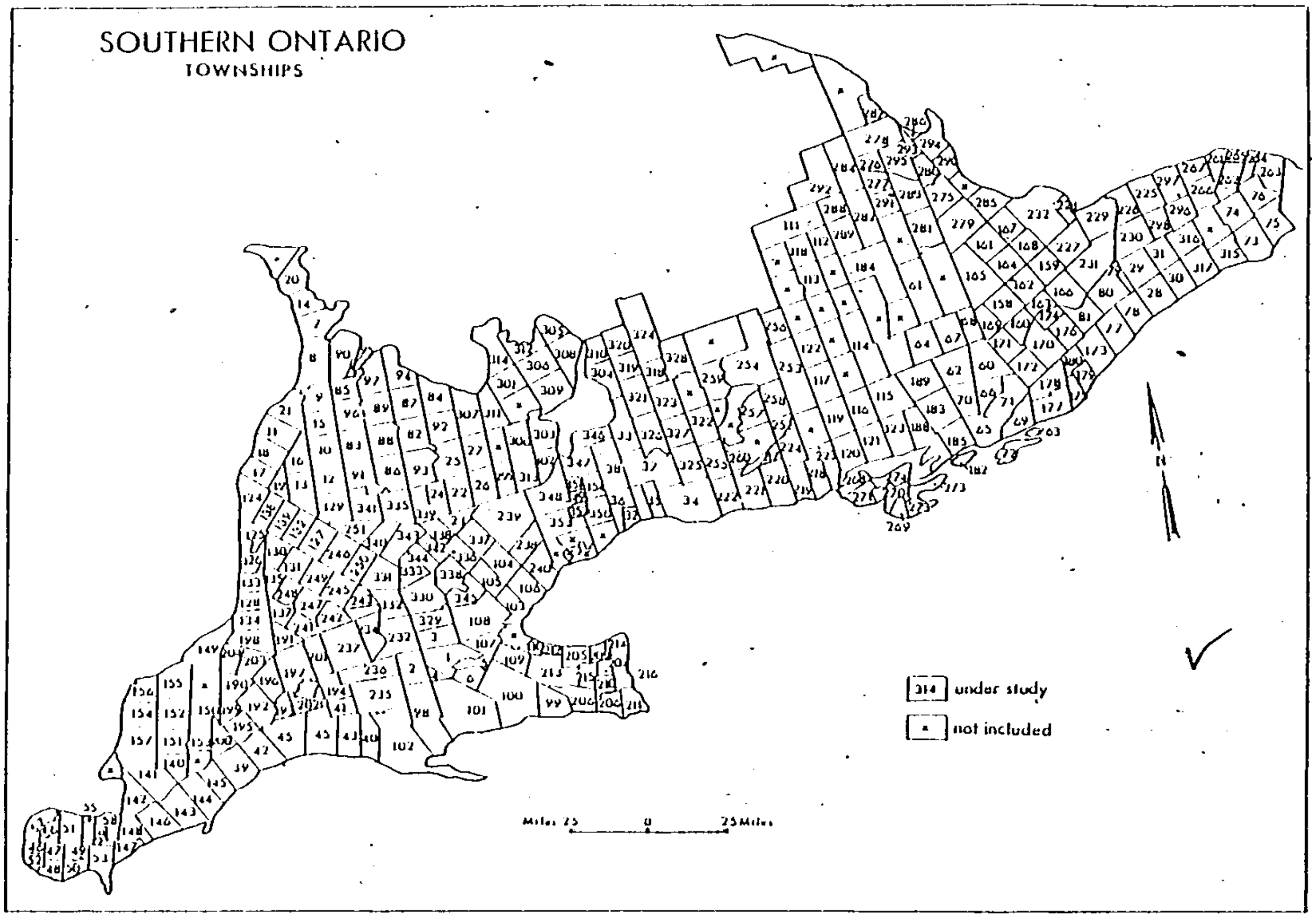
SOUTHERN ONTARIO
TOWNSHIPS
314 under study
* not included
N
Miles 25 0 25 Miles

Fig.3

CHAPTER TWO

Methodology:

The principal objectives of this study were two: (i) to analyse the temporal trends and spatial patterns of change of the total farm area, cropland and summer fallow, and improved pasture, by counties of Southern Ontario, for a period of 25 years (1951-1976); and (ii) to measure the relationships between land use changes, population growth, distance of land from metropolitan areas, and soil capabilities, by townships, in a recent 5 year period 1971-1976.

Part 1:

In order to analyse the 25 year trend of changes in total farm area, cropland and summer fallow and improved pasture, a non-parametric trend analysis technique will be used. Such an analysis is appropriate when applied to data in an attempt to show whether the dependent variables exhibit a systematic tendency to increase or decrease in a linear fashion with change in an independent variable, such as time (Ferguson, 1965: p. 4). The method is based on ranks, and employs the sampling distribution of the statistic S as used in the definition of Kendall's coefficient of rank correlation <u>tau</u> (Ferguson, 1965: p. 6).

The basic principle of this method is that a function of Y = f(X) is said to be a monotonically increasing function if an increment in X is associated with an increment of Y. Similarly, if any increment in

X is associated with a decrease in Y, the function is said to be a monotonically declining function. Thus the method indicates the monotonicity of a function, and is suitable for temporal trend analysis.

To analyse the temporal trend of all dependent variables the following procedures will be employed:

(i) Thirty-nine counties will be considered as subjects N; each of the six census years (1951, 1956, 1961, 1966, 1971 and 1976) will be considered as treatment variables K, (K = 6).

(ii) The data for each variable will be ranked for each subject from 1 to K ordered treatments.

(iii) Two columns of ranks will be compared at a time, assigning weights of +1, 0, and -1 for rank pairs in their natural order, tied and in an inverse order. The weights for each comparison of two columns will be summated to obtain Sij. All K(K-1)/2 comparisons will be made.

(iv) The weights +1, 0, -1 from a comparison of the ranks for orthogonal polynomials will be obtained. The following weights for orthogonal polynomials will be used (after Ferguson, 1965: p. 42, Table 10):

No. of Treatment	Degree of Polynomials	Weights
6	1	+1+1+1+1+1+1+1+1+1+1+1+1+1+1+1
	2	-1-1-1-1 0-1-1 0+1 0+1+1+1+1+1

No. of Treatment	Degree of Polynomials	Weights
	3	+1+1+1-1+1-1-1-1-1-1-1+1-1+1+1
	4	-1+1+1-1 0+1+1 0+1 0-1-1-1-1-1
	5	+1+1+1-1+1-1+1-1-1+1+1+1-1-1+1

(v) The sum of the products of the values of Sij with the columns of weights +1, 0, -1 will be obtained from the ranks for orthogonal polynomials, to obtain Σs_1, Σs_2, Σs_3, Σs_4, and Σs_5.

(vi) The unity will then be subtracted from the absolute values of Σs_1, Σs_2, Σs_3, Σs_4, and Σs_5 as a continuity correction.

(vii) The sampling variance $\sigma \Sigma s_i{}^2$, and standard error of the values of Σs_1, Σs_2, Σs_3, Σs_4 and Σs_5 will be calculated using the formula:

$$\sigma \Sigma s_i 2 = \frac{NK(K-1)\ (2K+5)}{18}$$ since no tie occurred.

(viii) The values of si, corrected for continuity will be divided by the corresponding standard error to obtain values of the normal deviate Zi. The Zi value will be tested for significance at the 0.05 and 0.001 level for a directional test.

Part II:

To analyse the spatial patterns of change in total farm area, cropland and summer fallow, and improved pasture, township data will be employed as follows:

(i) The percentage change ($\pm$) in an area under each agricultural land use class will be calculated for each township thus:

$$\% \text{ change} = \frac{X_2 - X_1}{X_1} \times 100$$ where X_1 and X_2 represented the areas under each land class in 1971 and 1976 respectively.

(ii) For the purpose of analysing the spatial pattern of change and also for testing the normality of the data, the percentage change of each variable will be converted to standard Z-scores. For each variable, with 354 observations, the standard Z-scores will be calculated thus:

$$Z\text{-score} = \frac{x_i - \bar{x}}{S}$$ where $\bar{x}$ and S represented mean and standard deviation respectively.

Plotting the Z-scores the normality of the data will be tested (Taylor, 1977), and a decision made whether or not parametric statistics will be useful for further analysis.

(iii) Using different shades, the standard Z-scores will be mapped in choropleth form for each land use class. In order to visualize the spatial pattern of change, five Z-score ranges will be employed.

(a) $Z > 1.64$, (b) $0.82 > Z < 1.64$ (c) $-0.82 > Z < 0.82$ (d) $-1.64 > Z < -0.82$ (e) < -1.64.

<u>Part III</u>:

The choropleth maps will be tested for autocorrelation by means of Moran's test for a pattern in K-Colour maps (Taylor, 1977: p. 5).

First, a contiguity matrix will be constructed to show the contiguity between each of the areal units.

The entries in the matrix are known as $ij = i$ when i and j are contiguous, and $ij = 0$ when i and j are non-contiguous. The total number of joins or contiguous links occurring in the map pattern will be counted for 354 townships of the study area.

The next step will be to calculate the equation:

$$(x_i-\bar{x}) \quad (xj-\bar{x}) \quad ij$$

This equation will be calculated by first taking the mean ($\bar{x}$) of the data and subtracting it from x value for each contiguous township, thus yielding a value ($x-\bar{x}$) for each township in the matrix. Then the ($x-\bar{x}$) values for each pair of contiguous townships will be multiplied. For example, if township 1 were linked to township 2, the ($x-\bar{x}$) value for township 1 would be multiplied by the ($x-\bar{x}$) value for township 2. This will be done for each pair of townships that are contiguous, and their products will be summated.

Next, the $(x_i-\bar{x})^2$ values for each township will be calculated and summed for all townships. The uncorrected estimate of autocorrelation I value will then be calculated using the formula:

$$I = \frac{(x_i-\bar{x}) \ (x_j-\bar{x}) \ ij}{(x_i-\bar{x})^2}$$

Next, the value of autocorrelation coefficient (r_a) will be calculated with the formula: $r_a = n/l \times I$ where n represents the number of observations, and l the number of contiguous links. The statistic r_a may be interpreted as a measure of autocorrelation in which positive autocorrelation produces a positive score to a maximum of +1, and negative autocorrelation produces a negative score to a maximum of -1 (Taylor, 1977: p. 122).

Next, the Var (I) under randomness is defined as:

$$Var(I) = E(I)^2 - (E(I))^2$$

The expected value of I under randomness or E (I) will be calculated from the equation:

$$E\ (I) = \frac{-1}{n(n-1)}$$

The value of $E(I)^2$ will then be calculated using the formula:

$$E\ (I)^2 = \frac{1(1+2p^2) + 2K(p+2p^2) + 31(1-1) -2Kp^2\ (n-1)}{n^2(n+}$$

where $p = -(n-1)^{-1}$, and $K = \sum_{j=1}^{n} 1j\ (1j-1)$.

The Zi - value (standard normal deviate statistic) is defined as: $Zi = \dfrac{I - E(I)}{\sqrt{Var\ (I)}}$

If the Zi value should fall below the Zcrit value of 1.96, then Ho 4,5, and 6 could be accepted that the spatial pattern of change in total farm area (H_o4) cropland and summer fallow (Ho5) and improved pasture (Ho6) is random and is a function of no spatial autocorrelation. If this should occur, the variables will then be subjected to a stepwise multiple regression analysis as outlined below.

Part IV:

In a stepwise multiple regression analysis, using the Statistical Analysis System (SAS), six independent variables for the total farm area, cropland and summer fallow, and improved pasture will be tested separately for their degree of association with agricultural land use changes in the study area.

The set of independent variables chosen for the analysis were:

X_1 = percent of total population change in 1971-1976,

X_2 = percent of total land under good soil,

X_3 = percent of total land under medium soil,

X_4 = percent of total land under poor soil,

X_5 = percent of total land under organic soil,

X_6 = distance in miles of each township from the nearest metropolitan city (built up area) with population of over 100,000.

All the variables will be tested for normality by Kolmogrov-Smirnov tests and appropriate data tranformation will be employed to achieve the normality of the data.

At each step in the analysis, the F-observed values for the partial correlation coefficients will be obtained and their associated F-critical values will be calculated at the .05 level of significance, and $df_1 = 1$, $df_2 = n-K-1$.

The null hypotheses (H_o, 7,8,9) will be tested at each step whether any significant correlation exists between the independent and the dependent variables.

The multiple correlation coefficients (R_{y} 1,2,3,4,5,6) and the multiple coefficient of determination statistics will be extracted from the programmes. An F-test at the 0.05 level of significance will be used to test the null hypotheses (Ho 7, Ho 8 and Ho 9).

CHAPTER THREE

AGRICULTURAL LAND USE CHANGE IN SOUTHERN ONTARIO, 1951-76

This chapter is devoted to the analysis of temporal trend of agricultural land use in Southern Ontario at the county level. Non-parametric trend analysis is employed to assess the changes of total farm area, cropland and summer fallow, and improved pasture.

Change in Total farm Area:

While using non-parametric trend analysis, thirty-nine counties of the study area were considered as N subjects. Each of the six census years (1951, 1956, 1961, 1966, 1971, 1976) was considered as a treatment variable K, thus, K = 6.

At the next step, the data for total farm area were ranked for each subject from 1 to K ordered treatment (Table 1). For each rank pairs, the assigned weights were +1, 0, and -1 in their natural order, tied and inverse order respectively (Table 2).

Two columns of ranks were compared at a time, and all K(K-1)/2 comparisons were made. The weights for each comparisons of two columns were summated to obtain Sij (Table 3). The weights +1, 0, and -1 from a comparison of the ranks for orthogonal polynomials were obtained (Table 3).

The sum of the products of the values of Sij with the columns of weights +1, 0, and -1 were obtained from the ranks for orthogonal polynomials to obtain s_1, s_2, s_3, s_4, and s_5. The values of s_1, s_2, s_3, s_4.

TABLE 1

HIGHER ORDER TREND ANALYSIS FOR
TOTAL FARM AREA: SOUTHERN ONTARIO COUNTIES, 1951-76

N	Name	1951	1956	1961	1966	1971	1976
1	Brant	223402	218707	204451	209045	197794	183588
2	Bruce	749196	744028	746329	724099	683736	653339
3	Carleton	473644	444509	406681	375330	390180	331526
4	Dufferine	327762	309992	300289	288367	254832	227006
5	Dundas	226963	220465	208272	207006	189260	178513
6	Durham	765156	724741	688940	659089	583793	368417
7	Elgin	421379	418077	402896	404276	394099	386134
8	Essex	375636	377144	379962	367501	359203	349839
9	Frontenac	502907	455704	389984	347937	292180	250391
10	Glengarry	264383	269727	263061	250569	213267	190721
11	Green-ville	227642	215661	194826	193636	162157	134274
12	Grey	963068	955077	899673	859205	760193	693433
13	Hald-imand	623799	624786	607663	601952	575675	538653
14	Hastings	651131	604769	564692	512562	436610	361420
15	Huron	783556	775063	765135	752043	742965	727346
16	Kent	553931	550592	557133	555313	559811	547273
17	Lambton	613215	605142	600850	596387	574401	567805
18	Lanarc	529069	516081	489599	462873	393283	328503
19	Leeds	426616	411507	394137	378894	326309	284243
20	Lennox	361891	333401	313933	300956	260281	236253

TABLE ONE CONT'D

N	Name	1951	1956	1961	1966	1971	1976
21	Middlesex	730459	717361	696040	679586	662092	638742
22	Niagara	334058	315499	291560	284244	252544	227924
23	Halton	204579	186502	163277	153195	126912	117866
24	North-umberland	395496	381913	368749	356429	318666	316163
25	Oxford	459805	454009	449321	435656	428976	426826
26	Peel	256801	227872	207932	201618	163588	148049
27	Perth	515333	515192	511303	508387	500382	491190
28	Peterboro	358766	343330	327070	299028	259725	294253
29	Pr. Ed. Is.	218329	219270	207044	210054	194457	178417
30	Presscot	271068	256580	257832	255105	233051	205745
31	Renfrew	828056	743272	696287	654876	539711	450609
32	Russel	208927	206898	198534	195421	122489	104643
33	Simcoe	777432	759358	704874	661545	588323	585395
34	Stormont	232522	216392	192364	193326	168483	148721
35	Waterloo	291789	290999	276636	267460	249051	242291
36	Wellington	606630	594972	570823	557724	512595	484928
37	Wentworth	232659	215484	198139	180424	171070	153655
38	Victoria	477508	466908	454157	432439	378158	392961
39	York	403304	345073	313087	292949	255922	231025

Source: Census of Canada, Agriculture, Ontario, 1951, 1956, 1961, 1966, 1971, 1976

TABLE 2

RANKS FOR TREATMENTS I-VI
FOR TOTAL FARM AREA

N	I	II	III	IV	V	VI
1	6	5	3	4	2	1
2	6	4	5	3	2	1
3	6	5	4	2	3	1
4	6	5	4	3	2	1
5	6	5	4	3	2	1
6	6	5	4	3	2	1
7	6	5	4	3	2	1
8	4	5	6	3	2	1
9	6	5	4	3	2	1
10	5	6	4	3	2	1
11	6	5	4	3	2	1
12	6	5	4	3	2	1
13	5	6	4	3	2	1
14	6	5	4	3	2	1
15	6	5	4	3	2	1
16	3	1	5	4	6	2
17	6	5	4	3	2	1
18	6	5	4	3	2	1
19	6	5	4	3	2	1
20	6	5	4	3	2	1
21	6	5	4	3	2	1
22	6	5	4	3	2	1
23	6	5	4	3	2	1
24	6	5	4	3	2	1
25	6	5	4	3	2	1

cont'd .....

TABLE 2 CONT'D

N	I	II	III	IV	V	VI
26	6	5	4	3	2	1
27	6	5	4	3	2	1
28	6	5	4	3	1	2
29	5	6	3	4	2	1
30	6	4	5	3	2	1
31	6	5	4	3	2	1
32	6	5	4	3	2	1
33	6	5	4	3	2	1
34	6	5	3	4	2	1
35	6	5	4	3	2	1
36	6	5	4	3	2	1
37	6	5	4	3	2	1
38	6	5	4	3	1	2
39	6	5	4	3	1	2

Source: Author

TABLE 3

CALCULATION OF Σs_1, Σs_2, Σs_3, Σs_4, Σs_5, FOR DATA OF TOTAL FARM AREA: 1951-76

Col. Compared	S_{ij}	Weights from Ranks of Ortho. Polynomials s_1	s_2	s_3	s_4	s_5
I-II	-35	1	-1	1	-1	1
I-III	-37	1	-1	1	1	1
I-IV	-38	1	-1	1	1	1
I-V	-38	1	-1	-1	-1	-1
I-VI	-39	1	0	1	0	1
II-III	-34	1	-1	-1	1	-1
II-IV	-38	1	-1	-1	1	1
II-V	-38	1	0	-1	0	-1
II-VI	-39	1	1	-1	1	-1
III-IV	-35	1	0	-1	0	-1
III-V	-38	1	1	-1	-1	1
III-VI	-39	1	1	1	-1	1
IV-V	-38	1	1	-1	-1	-1
IV-VI	-39	1	1	1	-1	-1
V-VI	-38	1	1	1	1	1
		$\Sigma s_1=-563$	$\Sigma s_2=-12$	$\Sigma s_3=35$	$\Sigma s_4=79$	$\Sigma s_5=-42$

Source: Author

Σs_5 were calculated as:

$$\Sigma s_1 = -563$$
$$\Sigma s_2 = -12$$
$$\Sigma s_3 = 35$$
$$\Sigma s_4 = 79$$
$$\Sigma s_5 = -42$$

One was then subtracted from the absolute values of Σs_1, Σs_2, Σs_3, Σs_4, and Σs_5 as a continuity correction. Thus:

$$\Sigma s_1 \; -1 = |-563| -1 = 562$$
$$\Sigma s_2 \; -1 = |-12| -1 = 11$$
$$\Sigma s_3 \; -1 = 35 -1 = 34$$
$$\Sigma s_4 \; -1 = 79 -1 = 78$$
$$\Sigma s_5 \; -1 = |-42| -1 = 41$$

Next, the sampling variance $\sigma \Sigma s_i{}^2$ and standard deviation of the values of Σs_1, Σs_2, Σs_3, Σs_4 and Σs_5 were calculated using the formula:

$$\sigma \Sigma s_i{}^2 = \frac{NK(K-1)(2K+5)}{18}$$
$$= \frac{39.6(6-1)(2.6+5)}{18}$$
$$= \frac{234(5)(12+5)}{18}$$
$$= \frac{19890}{18}$$
$$= 1105$$

Therefore, the standard deviation $\sigma \Sigma s_i = 33.24$.

The values of Σsi, corrected for continuity, were divided by the corresponding standard deviation to obtain the values of the standard normal deviate Z_1.

Thus for

$$\Sigma s_1,\ Z_1 = \frac{\Sigma s_1 - 1}{\sigma \Sigma si} = \frac{|-563|-1}{33.24} = 16.90$$

$$\Sigma s_2,\ Z_2 = \frac{s_2 - 1}{\sigma \Sigma si} = \frac{|-12|-1}{33.24} = 0.33$$

$$\Sigma s_3,\ Z_3 = \frac{\Sigma s_3 - 1}{\sigma \Sigma si} = \frac{35 - 1}{33.24} = 1.02$$

$$\Sigma s_4,\ Z_4 = \frac{s_4 - 1}{\sigma \Sigma si} = \frac{79 - 1}{33.24} = 2.34$$

$$\Sigma s_5,\ Z_5 = \frac{\Sigma s_5 - 1}{\sigma \Sigma si} = \frac{|-45| - 1}{33.24} = 1.32$$

The Z_i value was tested for significance at 0.05 level for a directional test (Ferguson, 1965: p. 27, Table 5); and was found significant.

The value of Z_1 was equal to 16.90 which meant that the total farm area, when viewed as a whole (1951-1976) showed a significant monotonic tendency to decline over a 25 year period between 1951-1976. The value of Z_2 was equal to 0.33 and meant that during the period between 1951-1956, total farm area had shown no significant tendency to change. The Z_3, Z_4 and Z_5 values indicated that total farm area in Southern Ontario counties were significantly declining in the following years after 1956.

Since the Z_1 value was significant and showed that the total farm area had monotonically declined over 25 year time period, the null hypothesis was rejected and the hypothesis (H 1) was accepted that in Southern Ontario, in the last 25 years, total farm area had been monotonically declining.

Change in Cropland and Summer Fallow:

Using non-parametric trend analysis, the trend of change in cropland and summer fallow was analysed. Thirty-nine counties of the study area were considered as N subjects, and each of the six census years (1951, 1956, 1961, 1966, 1971, and 1976) was considered as a treatment variable, K, thus K = 6.

The data for cropland and summer fallow were ranked for each subject from 1 to K ordered treatments (Table 4). For each rank pairs, weights +1, 0, and -1 were assigned for their natural order, tied and inverse order respectively (Table 5).

Two columns of ranks were compared at a time and all K(K-1)/2 comparisons were made. The weights for each comparisons of two columns were summated to obtain Sij (Table 6). The weights +1, 0, and -1 from a comparison of the ranks for orthogonal polynomials were obtained (Table 6).

The sum of the products of the values of Sij with the columns of weights +1, 0, -1 were obtained from the ranks for orthogonal polynomials to obtain Σs_1, Σs_2, Σs_3, Σs_4, and Σs_5. The values of Σs_1, Σs_2, Σs_3, Σs_4,

TABLE 4

HIGHER ORDER TREND ANALYSIS FOR CROPLAND AND SUMMER FALLOW:
SOUTHERN ONTARIO COUNTIES: 1951-1976

N	Name	1951	1956	1961	1966	1971	1976
1	Brant	132415	133581	128877	144275	143059	144184
2	Bruce	322466	290936	285677	297015	280852	320458
3	Carleton	201174	178616	163581	166595	177919	178251
4	Dufferine	158942	148860	145616	149174	130038	142140
5	Dundas	124526	109728	109843	114306	103718	109296
6	Durham	340171	313031	297506	298974	280213	215170
7	Elgin	221773	238319	232819	260195	269173	288880
8	Essex	290849	307662	317669	321047	320125	326640
9	Frontenac	123408	113153	94178	96651	81425	83693
10	Glengarry	123578	120154	117408	117940	99710	101417
11	Greenville	85273	70970	65102	71673	58196	58173
12	Grey	401271	366951	345079	348498	299683	326892
13	Haldimand	372073	374029	371809	358464	3387662	395241
14	Hastings	190154	170185	157164	154737	135138	134658
15	Huron	390236	381993	377862	420380	450992	517549
16	Kent	400029	431921	447865	468905	486307	490324
17	Lambton	291580	313807	320807	361715	374470	413072
18	Lanarc	121727	115399	107385	106909	90218	94264
19	Leeds	131762	119010	115877	118745	96019	100205
20	Lennox	121391	108502	102622	103624	89253	92536

TABLE 4 CONT'D

N	NAME	1951	1956	1961	1966	1971	1976
21	Middlesex	333493	350468	334427	377751	408235	457416
22	Niagara	205219	193605	186150	176890	177659	178088
23	Halton	110416	94240	86496	87539	74755	100611
24	North-umberland	169087	180674	153345	156780	137279	161991
25	Oxford	271604	269388	270417	284951	307177	334051
26	Peel	142755	118722	112212	118513	98556	102126
27	Perth	307182	306687	309837	333488	341667	380550
28	Peterboro	113676	105089	97480	98107	84386	120263
29	Pr.Ed.Is.	107811	102479	99525	103573	96875	101734
30	Presscot	148989	128993	139295	144623	124487	124442
31	Renfrew	203875	185022	174747	178427	144926	144903
32	Russel	112468	104330	104412	111484	71456	70386
33	Simcoe	384142	359188	340604	345482	318814	359016
34	Stormont	105208	93590	87362	90199	76558	82347
35	Waterloo	189172	181261	176581	182643	179327	187301
36	Wellington	336485	312819	307550	327931	309591	342578
37	Wentworth	137632	127269	118505	115268	118813	117344
38	Victoria	144246	133611	124594	128784	112538	141648
39	York	240602	194557	182197	181423	164739	163020

Source: Census of Canada, Agriculture, Ontario, 1951, 1956, 1961, 1966, 1971 1976

TABLE 5

RANKS FOR TREATMENTS I-VI
FOR CROPLAND AND SUMMER FALLOW

N	I	II	III	IV	V	VI
1	2	3	1	6	4	5
2	6	3	2	4	1	5
3	6	5	1	2	3	4
4	6	4	3	5	1	2
5	6	3	4	5	1	2
6	6	5	3	4	2	1
7	1	3	2	4	5	6
8	1	2	3	5	4	6
9	6	5	3	4	1	2
10	6	5	3	4	1	2
11	6	4	3	5	2	1
12	6	5	3	4	1	2
13	3	4	2	1	5	6
14	6	5	4	3	2	1
15	3	2	1	4	5	6
16	1	2	3	4	5	6
17	1	2	3	4	5	6
18	6	5	4	3	1	2
19	6	5	3	4	1	2
20	6	5	3	4	1	2
21	1	3	2	4	5	6
22	6	5	4	1	2	3
23	6	4	2	3	1	5
24	5	6	2	3	1	4
25	3	1	2	4	5	6

cont'd.....

TABLE 5 CONT'D

N	I	II	III	IV	V	VI
26	6	5	3	4	1	2
27	2	1	3	4	5	6
28	5	6	2	3	1	6
29	6	4	2	5	1	3
30	6	3	4	5	2	1
31	6	5	3	4	2	1
32	6	3	4	5	2	1
33	6	5	2	3	1	4
34	6	5	3	4	1	2
35	6	3	1	4	2	5
36	5	3	1	4	2	6
37	6	5	3	1	4	2
38	6	4	2	3	1	5
39	6	5	4	3	2	1

Source: Author

TABLE 6

CALCULATION OF Σs_1, Σs_2, Σs_3, Σs_4, Σs_5,
FOR DATA OF CROPLAND AND SUMMER FALLOW: 1951-76

Col. Compared	S_{ij}	Weights from Ranks of Ortho. Polynomials s_1	s_2	s_3	s_4	s_5
I-II	-34	1	-1	1	-1	1
I-II	-34	1	-1	1	1	1
I-IV	-28	1	-1	1	1	1
I-V	-29	1	-1	-1	-1	-1
I-VI	-25	1	0	1	0	1
II-III	-31	1	-1	-1	1	-1
II-IV	27	1	-1	-1	1	1
II-V	11	1	0	-1	0	-1
II-VI	19	1	1	-1	1	-1
III-IV	20	1	0	-1	0	1
III-V	13	1	1	-1	-1	1
III-VI	21	1	1	1	-1	1
IV-V	11	1	1	-1	-1	-1
IV-VI	19	1	1	1	-1	-1
V-VI	34	1	1	1	1	1
		$\Sigma s_1=-5$	$\Sigma s_2=212$	$\Sigma s_3=88$	$\Sigma s_4=82$	$\Sigma s_5=-6$

Source: Author

Σs_5 were calculated as:

$\Sigma s_1 = -5$

$\Sigma s_2 = 212$

$\Sigma s_3 = 88$

$\Sigma s_4 = -82$

$\Sigma s_5 = -6$

One was then subtracted from the absolute values of Σs_1, Σs_2, Σs_3, Σs_4, and Σs_5 as a continuity correction. Thus:

$\Sigma s_1 \; -1 = |-5|-1 = 4$

$\Sigma s_2 \; -1 = 212 -1 = 211$

$\Sigma s_3 \; -1 = 88 \; -1 = 87$

$\Sigma s_4 \; -1 = |-82|-1 = 81$

$\Sigma s_5 \; -1 = |-61|-1 = 5$

Next, the sampling variance $\sigma\Sigma s_i{}^2$ and standard deviation $\sigma\Sigma s_i$ of the values of Σs_1, Σs_2, Σs_3, Σs_4, and Σs_5 were calculated using the formula:

$$\sigma\Sigma s_i{}^2 = \frac{NK(K-1)(2K+5)}{18}$$

$$= \frac{39.6(6-1)(2.6+5)}{18}$$

$$= \frac{234(5)(12+5)}{18}$$

$$= \frac{19890}{18}$$

$$= 1105$$

Therefore, the standard deviation $\sigma\Sigma s_i$ was calculated as 33.24.

The values of Σsi, corrected for continuity were divided by the corresponding standard deviation to obtain the values of the standard normal deviate Zi. Thus for,

$$\Sigma s_1,\ Z_1 = \frac{\Sigma s_1 - 1}{\sigma \Sigma si} = \frac{|-5|-1}{33.24} \doteq 0.12$$

$$\Sigma s_2,\ Z_2 = \frac{\Sigma s_2 - 1}{\sigma \Sigma si} = \frac{212 - 1}{33.24} = 6.35$$

$$\Sigma s_3,\ Z_3 = \frac{\Sigma s_3 - 1}{\sigma \Sigma si} = \frac{88 - 1}{33.24} = 2.60$$

$$\Sigma s_4,\ Z_4 = \frac{\Sigma s_4 - 1}{\sigma \Sigma si} = \frac{|-82|-1}{33.24} = 2.43$$

$$\Sigma s_5,\ Z_5 = \frac{\Sigma s_5 - 1}{\sigma \Sigma si} = \frac{|-6|-1}{33.24} = 0.15$$

The Z_1 value was tested for significance at 0.05 level for a directional test (Ferguson, 1965: p. 27, Table 5); and was not found significant.

The value of Z_1 was equal to 0.12 which meant that cropland and summer fallow in the study area, when viewed as a whole function showed no significant tendency to increase or decrease and had no tendency to decline monotonically over a 25 year period between 1951-1976. The value of Z_2 was equal to 6.35 which meant that during the period between 1956-1976, change in cropland and summer fallow was significant. The values of Z_3 and Z_4 were equal to 2.60 and 2.43 respectively and meant a significant change in cropland and summer fallow between 1961-1976. The value of Z_5 was equal to 0.15 which meant that in between 1971 and 1976 change was not significant.

Since the value of Z_i was not significant, the null hypothesis (H_o2) was accepted that in the study area, during the 25 year period between 1951-1976 cropland and summer fallow was not monotonically declining.

Change in Improved Pasture:

Using non-parametric trend analysis, the trend of change in improved pasture in Southern Ontario, over a period of 25 years between 1951-1976 was analysed. As the first step, thirty-nine counties of the study area were considered as N subjects, and each of the six census years (1951, 1956, 1961, 1966, 1971, and 1976) was considered as K, thus K = 6.

At the next step, the data for improved pasture were ranked for each subject from 1 to K ordered treatments. (Table 7). For each rank pairs, assigned weights were +1, 0, and -1 in their natural order, tied and inverse order respectively (Table 8).

Two columns of ranks were compared at a time and all K(K-1)/2 comparisons were made. The weights for each comparisons of two columns were summated to obtain Sij (Table 9). The weights +1, 0, and -1 from a comparison of the ranks for orthogonal polynomials were obtained (Table 9).

The sum of the products of the values of Sij with the columns of weights +1, 0, and -1 were obtained from the ranks for orthogonal polynomials to obtain Σs_1, Σs_2,

TABLE 7

HIGHER ORDER TREND ANALYSIS FOR IMPROVED PASTURE
SOUTHERN ONTARIO COUNTIES: 1951-76

N	Name	1951	1956	1961	1966	1971	1976
1	Brant	33872	31792	28276	20769	14513	8669
2	Bruce	201578	233163	230670	223017	207527	176083
3	Carleton	98215	110610	94088	82369	74572	53197
4	Dufferine	71325	75505	79960	63282	58266	37197
5	Dundas	47092	58006	50039	48439	44927	32233
6	Durham	138378	139898	133276	124718	95659	52957
7	Elgin	77521	71256	64689	52042	33898	22955
8	Essex	35615	21875	17702	10919	5573	2859
9	Frontenac	37969	57597	53565	49478	37120	30005
10	Glengarry	32814	64851	45598	41767	36455	29094
11	Greenville	35916	38605	31032	34033	26435	18593
12	Grey	145949	188510	194479	184721	172391	130708
13	Haldimand	79112	84702	79671	63444	41576	23937
14	Hastings	63653	66123	57270	53659	46570	35425
15	Huron	207733	225602	227496	182303	143798	86069
16	Kent	65290	48786	34440	32814	21229	19405
17	Lambton	171167	146056	138044	118712	79868	58902
18	Lanarc	47273	54381	49537	53501	49798	39540
19	Leeds	49850	42650	44915	47295	45250	40421
20	Lennox	41219	50597	44504	38378	29658	28143

TABLE 7 CONT'D

N	Name	1951	1956	1961	1966	1971	1976
21	Middlesex	171971	181033	182808	158750	111610	75827
22	Niagara	50121	49711	39406	31480	21072	11327
23	Halton	36302	38572	32605	28250	17327	12439
24	North-umberland	54009	62260	61310	57246	44731	40263
25	Oxford	85411	91475	88840	69870	49248	30049
26	Peel	51261	62877	54590	38930	28113	19313
27	Perth	131900	134373	132223	110338	90157	53920
28	Peterboro	55641	54519	60903	51214	38944	45524
29	Pr.Ed.IS.	34484	37223	34988	33368	23086	17644
30	Presscot	63902	73843	65126	64466	61124	39740
31	Renfrew	85181	92203	96721	79631	76115	67268
32	Russel	49349	55649	50585	47239	30103	16288
33	Simcoe	93690	122795	121947	116591	80733	65822
34	Stormont	35120	43695	35346	33077	29045	20699
35	Waterloo	40861	46656	44544	35386	24108	17458
36	Wellington	121338	141808	134813	113676	87898	51858
37	Wentworth	33939	33161	28168	22777	14860	8391
38	Victoria	86999	92693	96892	85260	60844	65710
39	York	50877	57899	50537	41258	27182	20120

Source: Census of Canada, Agriculture, Ontario, 1951, 1956, 1961, 1966, 1971, 1976.

TABLE 8

RANKS FOR TREATMENTS I-VI
FOR IMPROVED PASTURE

N	I	II	III	IV	V	VI
1	6	5	4	3	2	1
2	2	6	5	4	3	1
3	5	6	4	3	2	1
4	4	5	6	3	2	1
5	3	6	5	4	2	1
6	5	6	4	3	2	1
7	6	5	4	3	2	1
8	6	5	4	3	2	1
9	3	6	5	4	2	1
10	2	5	6	4	3	1
11	5	6	3	4	2	1
12	2	5	6	4	3	1
13	4	6	5	3	2	1
14	5	6	4	3	2	1
15	4	5	6	3	2	1
16	6	5	4	3	2	1
17	6	5	4	3	2	1
18	2	6	3	5	4	1
19	6	2	3	5	4	1
20	4	6	5	3	2	1
21	4	5	6	3	2	1
22	6	5	4	3	2	1
23	5	6	4	3	2	1
24	3	6	5	4	2	1
25	4	6	5	3	2	1

cont'd.....

TABLE 8 CONT'D

N	I	II	III	IV	V	VI
26	4	6	5	3	2	1
27	4	6	5	3	2	1
28	5	4	6	3	2	1
29	4	6	5	3	2	1
30	3	6	5	4	2	1
31	4	5	6	3	2	1
32	4	6	5	3	2	1
33	3	6	5	4	2	1
34	4	6	5	3	2	1
35	4	6	5	3	2	1
36	4	6	5	3	2	1
37	6	5	4	3	2	1
38	4	5	6	3	1	2
39	5	6	4	3	2	1

Source: Author.

TABLE 9

CALCULATION OF $\Sigma s_1, \Sigma s_2, \Sigma s_3, \Sigma s_4, \Sigma s_5$

FOR IMPROVED PASTURE
SOUTHERN ONTARIO COUNTIES: 1951-1976

Col. Compared	s_{ij}	s_1	s_2	s_3	s_4	s_5
I-II	+30	1	-1	1	-1	1
I-III	25	1	-1	1	1	1
I-IV	-30	1	-1	1	1	1
I-V	-35	1	-1	-1	-1	-1
I-VI	-39	1	0	1	0	1
II-III	-30	1	-1	-1	1	-1
II-IV	-38	1	-1	-1	1	1
II-V	-39	1	0	-1	0	-1
II-VI	-39	1	1	-1	1	-1
III-IV	-35	1	0	-1	0	1
III-V	-39	1	1	-1	-1	1
III-VI	-39	1	1	1	-1	1
IV-V	-39	1	1	-1	-1	-1
IV-VI	-39	1	1	1	-1	-1
V-VI	-39	1	1	1	1	1
		$\Sigma s_1=-425$	$\Sigma s_2=-78$	$\Sigma s_3=163$	$\Sigma s_4=10$	$\Sigma s_5=17$

Source: Author.

Σs_3, Σs_4 and Σs_5. The values of Σs_1, Σs_2, Σs_3, Σs_4 and Σs_5 were calculated as:

$$\Sigma s_1 = -425$$
$$\Sigma s_2 = -78$$
$$\Sigma s_3 = 163$$
$$\Sigma s_4 = 10$$
$$\Sigma s_5 = 17$$

Next, one was subtracted from the absolute values of Σs_1, Σs_2, Σs_3, Σs_4, and Σs_5 as a continuity correction. Thus:

$$\Sigma s_1 \ -1 = |-425| -1 = 424$$
$$\Sigma s_2 \ -1 = |-78| -1 = 77$$
$$\Sigma s_3 \ -1 = 163 -1 = 162$$
$$\Sigma s_4 \ -1 = 10 -1 = 9$$
$$\Sigma s_5 \ -1 = 17 -1 = 16$$

Next, the sampling variance $\sigma \Sigma s_i^{\,2}$ and the standard deviation of the values of Σs_1, Σs_2, Σs_3, Σs_4 and Σs_5 were calculated using the formula:

$$\sigma \Sigma s_i^{\,2} = \frac{NK(K-1)(2K+5)}{18}$$
$$= \frac{39.6(6-1)(2.6+5)}{18}$$
$$= \frac{234(5)(12+5)}{18}$$
$$= \frac{19890}{18}$$
$$= 1105$$

Therefore, standard deviation $\sigma \Sigma s_i = 33.24$.

The values of Σs_i, corrected for continuity were then divided by the corresponding standard deviation to obtain the values of the standard normal deviate Zl. Thus for:

$$\Sigma s_1, \quad Z_1 = \frac{\Sigma s_1 - 1}{\sigma \Sigma si} = \frac{|-425|-1}{33.24} = 12.76$$

$$\Sigma s_2, \quad Z_2 = \frac{\Sigma s_2 - 1}{\sigma \Sigma si} = \frac{|-78|-1}{33.24} = 2.31$$

$$\Sigma s_3, \quad Z_3 = \frac{\Sigma s_3 - 1}{\sigma \Sigma si} = \frac{163 - 1}{33.24} = 4.78$$

$$\Sigma s_4, \quad Z_4 = \frac{\Sigma s_4 - 1}{\sigma \Sigma si} = \frac{10 - 1}{33.24} = 0.27$$

$$\Sigma s_5, \quad Z_5 = \frac{\Sigma s_5 - 1}{\sigma \Sigma si} = \frac{17 - 1}{33.24} = 0.48$$

The Z_i value was tested for significance at 0.05 level for a directional test (Ferguson, 1965: p. 27, Table 5), and was found significant.

The Z_1 value was equal to 12.76 and the Σs_1 value was -425, all of which meant that in the study area, improved pasture when viewed as a whole function, showed significant monotonic tendency to decline over a 25 year period between 1951-1976. The Z_2 value was equal to 2.31 which meant that during the period between 1956-1976, the change in improved pasture in the study area was significant. The Z_3 value was equal to 4.78 which indicated that during the period between 1961 and 1976, change in improved pasture was significant. The Z_4 and Z_5 values were found 0.27 and 0.48 which indicated no significant change between 1966-1976.

Since the Z1 value indicated that in the study area, improved pasture had been monotonically declining over time, the null hypothesis was rejected and the hypothesis (H_3) accepted that, in Southern Ontario, during the 25 year period 1951-1976, improved pasture had montonically declined.

In summary, the above analysis of trends in agricultural land uses, revealed that in Southern Ontario, during the last 25 years (1951-1976), there was a significant monotonic decline in total farm area and improved pasture. Cropland and summer fallow had not experienced a significant decline, but fluctuations in the trend were noticed (Fig. 4), and the loss was only 1.27 percent over the 25 year period.

Considering 1951 as a base year, it was found that between 1951-1961, the total farm area had decreased in all the counties of Southern Ontario except Kent and Essex (Table 1). Highest percentage of loss of farmland had been noticed in the counties located in the Toronto centred "golden horseshoe" region where about 25 percent of the total farm area had decreased by that time. Counties in the eastern Ontario and the Canadian Shield had experienced about 20 percent loss of total farm area. Loss of farmland was least (less than 10 percent) in the counties of South and South-western Ontario; counties like Essex and Kent on the other hand had experienced an

TREND IN AGRICULTURAL LAND USE CHANGE:
SOUTHERN ONTARIO, 1951–'76

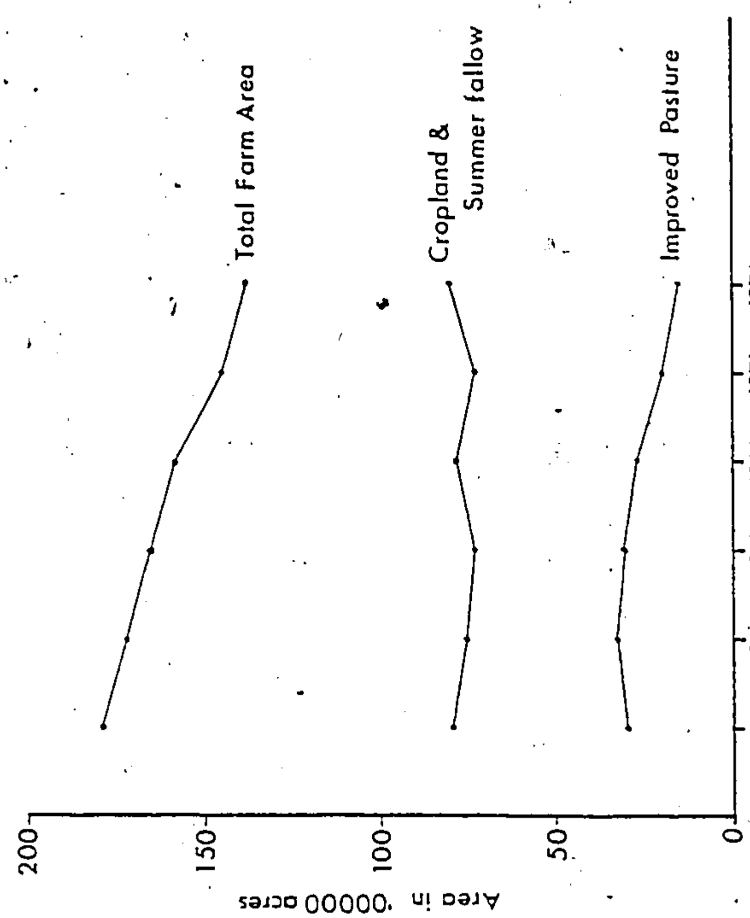

Fig. 4

increase of up to 1.2 percent. Between 1961-1976, all counties of the study area had lost their farmland (Fig. 5); and the average loss was 19 percent. Greatest loss was noticed in the counties located in the Toronto-centred "golden horseshoe" region and Ottawa-Carleton, where more than 40 percent of the total farm area had decreased between 1951-1976. Such a loss of total farmland was due to urban expansion (ARDA, 1972: p. 66).

Between 1951-1961, cropland and summer fallow in most of the counties of Southern Ontario remained constant(Table 4) . Some counties in Southwestern Ontario, such as Essex, Kent, Elgin, Perth, Lambton, and Haldimand-Norfolk, had shown an increment. During the next 15-year period, counties of Southwestern Ontario had experienced a significant increase (19 percent) in cropland and summer fallow, and some counties (Middlesex, Huron, Lambton, Kent, Oxford and Perth) had an increase of more than 20 percent (Fig. 6). Counties located in the eastern and central Ontario had experienced a decrease of cropland and summer fallow. Counties of Central Ontario such as York, Peel, Halton, Ontario had lost their cropland and summer fallow due to urban expansion (ARDA 1972: p. 66).

During the last 25 years, improved pasture had decreased by about 27 percent. Between the 1951-1961 period, counties like Brant, Essex, Kent and Lambton in Southwestern Ontario, Halton, York, Niagara and Wentworth in Central Ontario, and Carleton, Grenville, Hastings

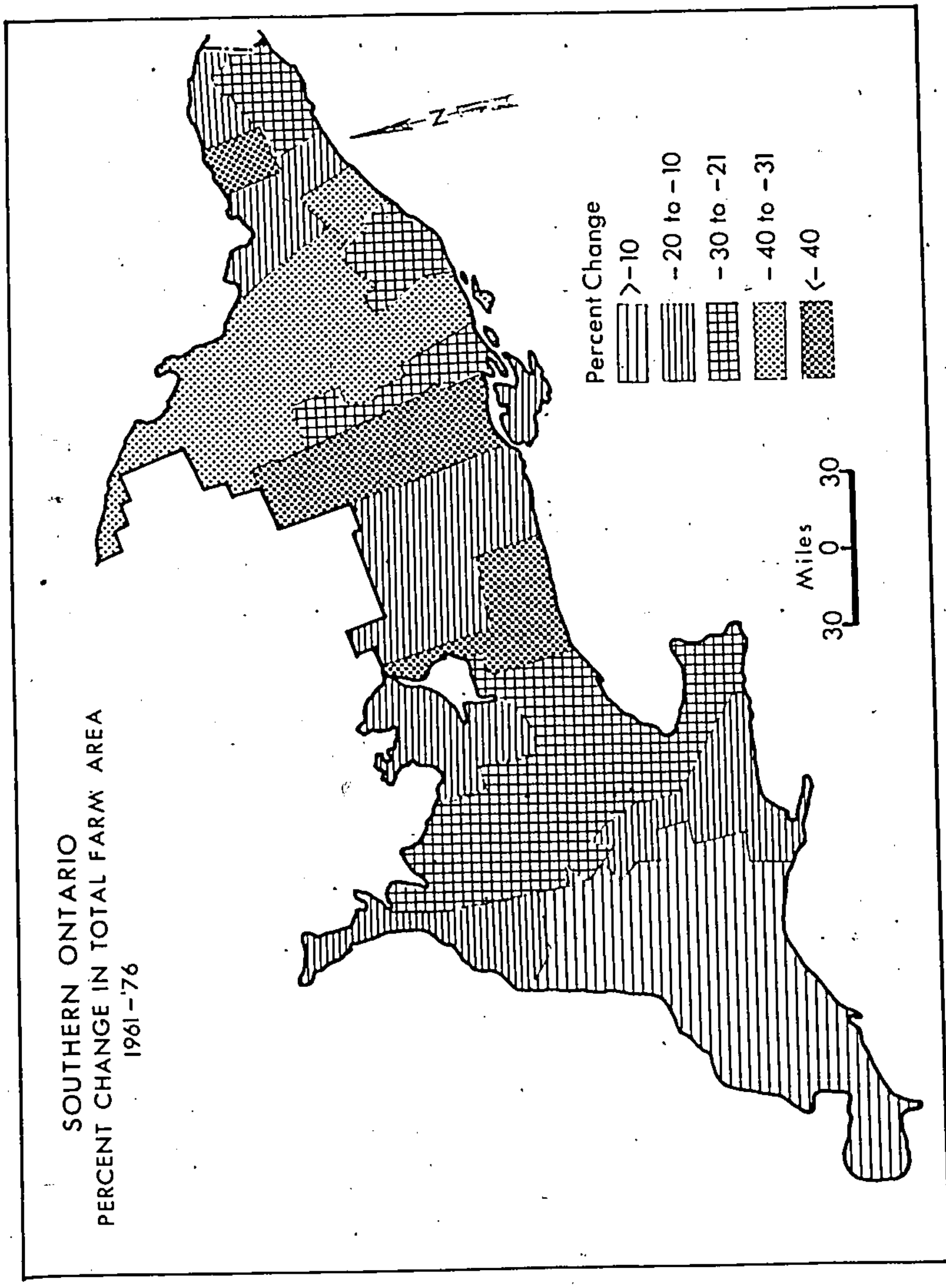
SOUTHERN ONTARIO
PERCENT CHANGE IN TOTAL FARM AREA
1961-'76
N
Percent Change
>-10
-20 to -10
-30 to -21
-40 to -31
<-40
Miles
30 0 30

Fig. 5.

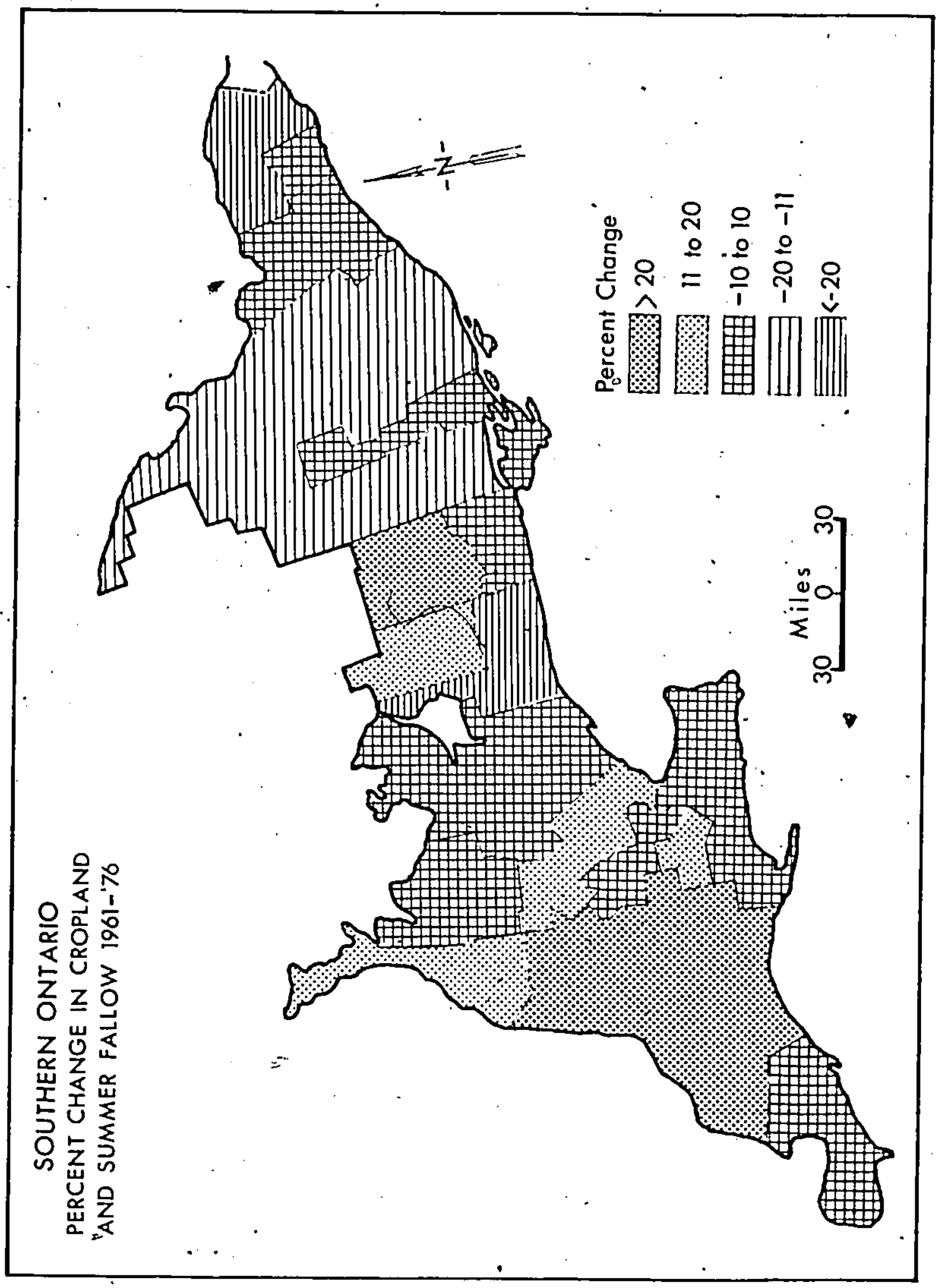
SOUTHERN ONTARIO
PERCENT CHANGE IN CROPLAND
AND SUMMER FALLOW 1961-'76
N
Percent Change
> 20
11 to 20
-10 to 10
-20 to -11
<-20
Miles
30 0 30

Fig. 6

and Leeds in Eastern Ontario had experienced a decrease in improved pasture (Table 7). Between 1961-1976, the acreage under improved pasture had decreased significantly in all the counties of Southern Ontario (Fig. 7) with high percentage decrease in South and Southwestern Ontario and lowest in the Canadian Shield.

The above analyses suggest that in Southern Ontario, total farm area and improved pasture declined monotonically, whereas cropland and summer fallow increased slightly at the county level. Loss of farmland was highest nearest the urban areas and in the Canadian Shield (where poor soil characterized the land). Counties of Southwestern Ontario with good soil had experienced minimum change of farmland. These patterns of change in total farm area, cropland and summer fallow and improved pasture at the county level should be reflected in the township level analyses even for a short term period.

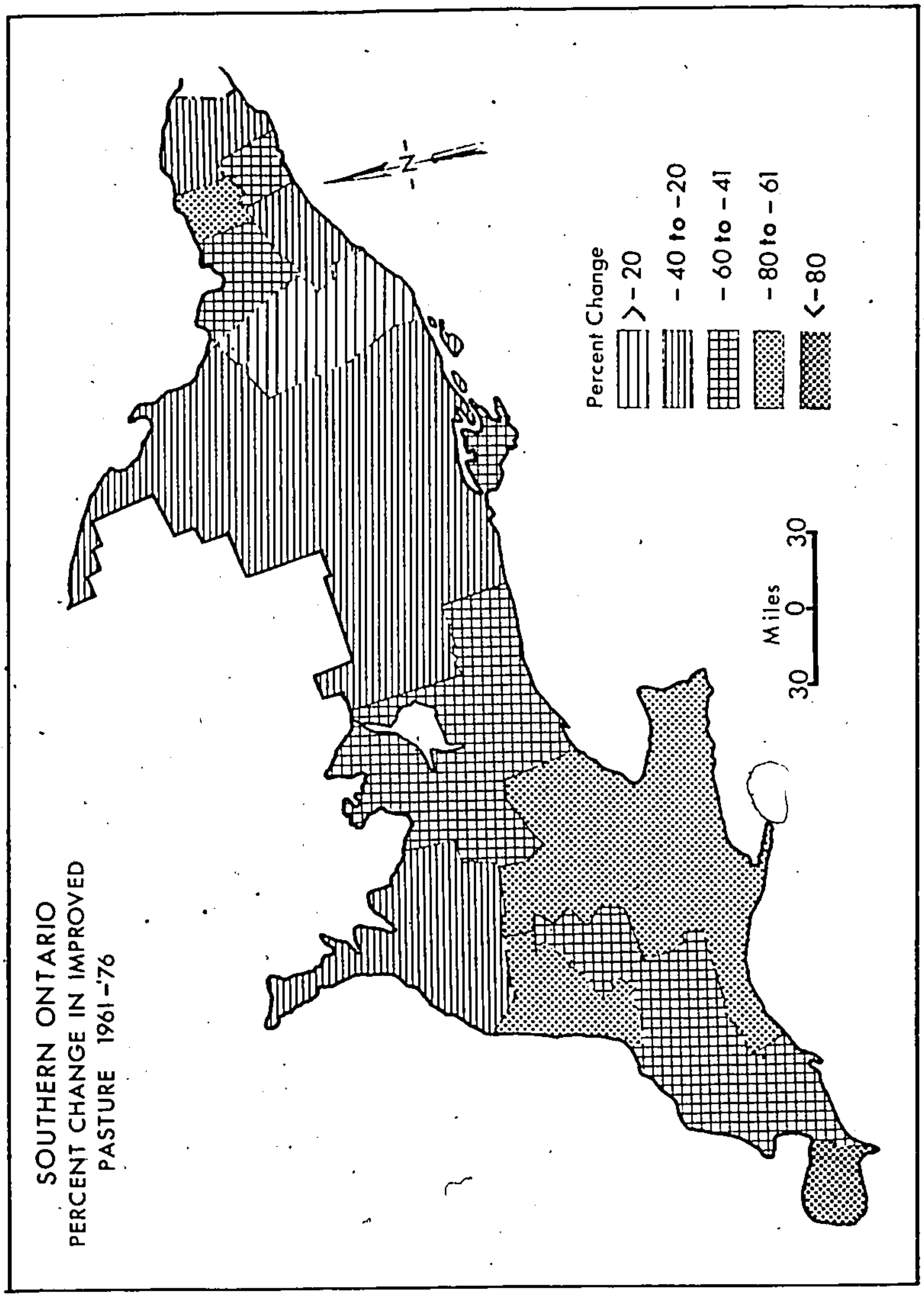
SOUTHERN ONTARIO
PERCENT CHANGE IN IMPROVED
PASTURE 1961-'76
N
Percent Change
> -20
-40 to -20
-60 to -41
-80 to -61
< -80
Miles
30 0 30

Fig. 7

CHAPTER FOUR

Spatial Pattern of Agricultural Land Use Change: 1971-1976

During 1971-1976, Southern Ontario townships had experienced a significant decline in total farm and improved pasture but a small increase in cropland and summer fallow. This chapter is devoted to the analysis of spatial pattern of these changes, their degree of randomness and the existence of spatial autocorrelation.

(a) Change in Total Farm Area:

During the period between 1971-1976, Southern Ontario townships had experienced a significant decrease of total farm area. The mean percentage of change ($\bar{x}$) in 354 townships was calculated as -7.43.

Out of 354 townships, 301 showed less than 20 percent decrease in total farm area. The standard Z-scores for these townships ranged between $-0.82 > Z < 0.82$ (Fig. 8). Within this range, a number of townships located in Southwestern Ontario, experienced an increment of less than 5 percent in total farm area.

Townships located in the Canadian Shield, in the northern part of Renfrew, Frontenac, Hastings and Lennox-Addington counties had experienced the greatest decline (more than 30 percent) of total farm area (Fig. 8). The Canadian Shield is noted for its poor soils and the loss of farm area may be due to abandonment of farming in favour of extensive outdoor recreational use rather than conversion into urban uses.

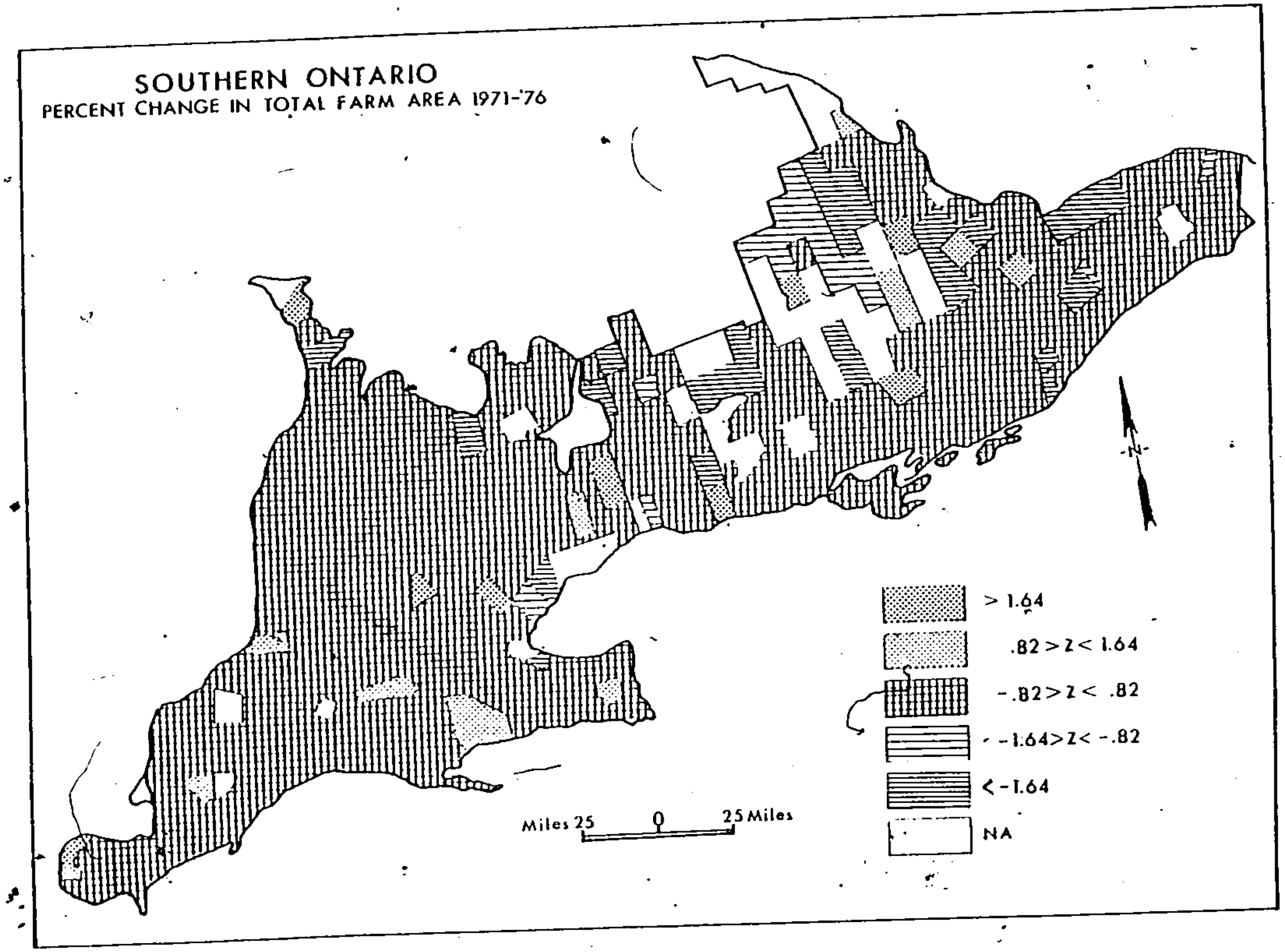
SOUTHERN ONTARIO
PERCENT CHANGE IN TOTAL FARM AREA 1971-'76
N
> 1.64
.82 > Z < 1.64
-.82 > Z < .82
-1.64 > Z < -.82
< -1.64
NA
Miles 25
0
25 Miles

Fig.8

The standard Z-scores calculated for these townships ranged between $Z < -1.64$ and $-1.64 > Z < -0.82$.

Townships closest to metropolitan Toronto, Hamilton, St. Catharines and Ottawa-Carleton had experienced the greatest decrease of total farm area. Rapid urbanization was the main cause of such decrease (ARDA, 1972: p. 107). Townships in Simcoe and Peterborough counties had experienced great decreases of total farm area; these counties are noted for their recreational importance.

The Moran's K-colour map analysis was used to test if autocorrelation existed in the map pattern of the total farm area. The total number of contiguous links occuring in the map pattern were 1043 for three hundred and fifty-four townships in the study area (Fig. 3).

The value of randomness (I), was calculated as 0.44 (Table 10). The value of r_a, which is a measure of autocorrelation was found 0.14. Next the expected value of I under randomness was calculated as $E(I) = -0.0083$. The value of Var(I) under randomness was as 0.729. Finally, the standard deviation (Zi) was calculated as 1.66, which fell below the Z critical value of 1.96, therefore the null hypothesis (H_o4) was accepted.

(b) <u>Change in Cropland and Summer Fallow</u>:

During the period 1971-1976, the Southern Ontario townships had experienced an increase in cropland and summer fallow. The mean percentage change in cropland and summer fallow in 354 townships of the study area was calculated as 7.24.

Out of 354 townships, 314 had experienced a moderate change (±) in cropland and summer fallow; the standard Z-scores calculated for these townships range in between -0.82 and 0.82 (Fig. 9). Townships located in Southwestern and Eastern Ontario had experienced an increase of more than 25 percent. On the other hand, townships located in the Canadian Shield, and around a growing metropolitan city like Toronto, Hamilton, St. Catharines or Ottawa had experienced a decrease of cropland and summer fallow, sometimes more than by 10 percent.

Townships located in the northern part of Renfrew, Frontenac, Hastings and Lennox-Addington counties had experienced greatest loss of cropland and summer fallow. The percentage decrease in these townships was found to be more than 25 percent (Z-score $-1.64 > Z < -0.82$ and $Z < -1.64$). These townships are located in the Canadian Shield with poor soils. Therefore, decline of cropland and summer fallow may be due to farm abandonment rather than conversion into urban uses.

Townships of northern Peterborough county had experienced a loss of cropland and summer fallow. Between 1971-1976, cropland and summer fallow of Burleigh, Anstruther, and Harvey townships declined by as much as 18 percent. These townships, located in the Canadian Shield were gaining recreational importance. Thus both the poor soil capability for agriculture in

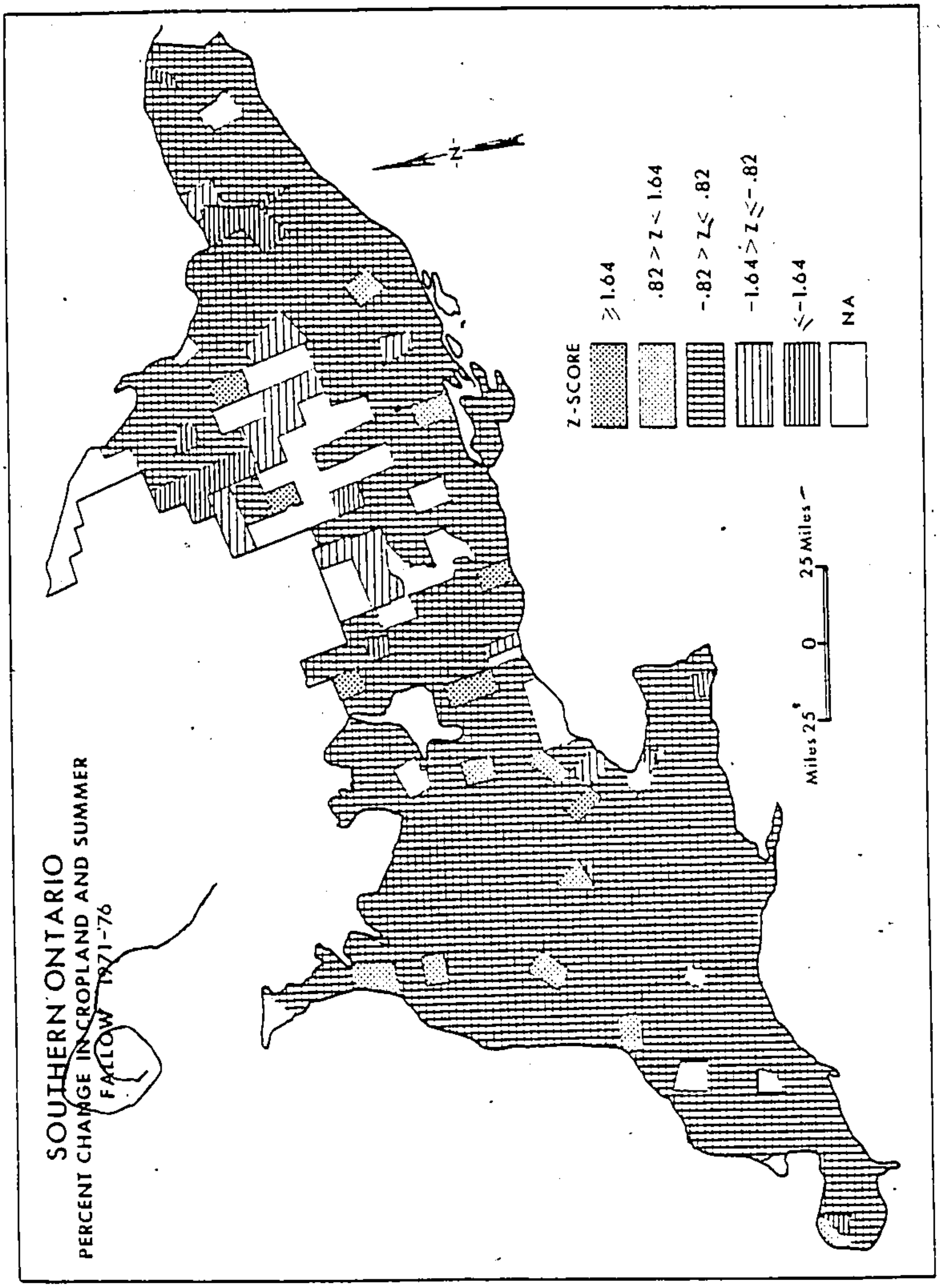
SOUTHERN ONTARIO
PERCENT CHANGE IN CROPLAND AND SUMMER FALLOW 1971-76
N
Z-SCORE
≥1.64
.82 > Z < 1.64
-.82 > Z ≤ .82
-1.64 > Z ≤ -.82
≤-1.64
NA
Miles 25
0
25 Miles

Fig.9

the Canadian Shield and the rising recreational importance of the area led to the decrease of cropland and summer fallow.

The Moran's K-colour map analysis was used to test if autocorrelation existed in the map pattern of cropland and summer fallow. The total number of contiguous links occuring in the map pattern were 1043 for 354 townships. The value of randomness (I) was calculated as 0.24 (Table 10). The value of r_a, which is a measure of autocorrelation was calculated as 0.081. Next the expected value of I under randomnes i.e. E(I) was found as -0.0083. The value of Var (I) under randomness, was the same as calculated for total farm area (0.729). The standard normal deviate (Z_i) was calculated as 0.92 which fell below the Z-critical value of 1.96, and the null hypothesis (Ho5) was therefore accepted.

(c) Changes in Improved Pasture:

During the 5 year period between 1971-1976, improved pasture in the study townships had decreased by 21.07 percent (mean $\bar{x}$). Out of 354 townships, 287 had experienced both increase (more than 10 percent) and a decrease (more than 50 percent) of improved pasture. The standard Z-scores calculated for these townships ranged between -0.82 and 0.82.

Townships located in the Canadian Shield, particularly, in the northern part of Renfrew, Lennox-Addington, Peterborough, Victoria, and Frontenac counties had experienced a significant increase of improved pasture (more than 60 percent). The standard Z-score calculated for these townships were ranged in between 0.82 and 1.64 (Fig. 10). From earlier discussion, it has been found that total farm area and cropland and summer fallow were decreasing in this part of the study area, which was due to poor soil capability of the area. But for improved pasture, it was found that these townships had experienced an increase of the acreage under this land use, therefore, it can be assumed that improved pasture is the best use for poor soil.

Townships located closest to metropolitan Toronto, Hamilton, St. Catherines, London, Kitchener-Waterloo, and Windsor had experienced greatest loss of improved pasture (more than 50 percent; Z-scores = $-1.64 > Z < -0.82$, and $Z < -1.64$. Urban expansion was the possible cause of such loss of improved pasture (ARDA, 1972; p. 67).

Moran's K-colour map analysis was used to test if any autocorrelation existed in the map pattern of improved pasture. The total number of contiguous links occuring in the map pattern were 1043 for 354 townships. The value for randomness (I), calculated by the formula, was equal to 0.40. The value of r_a which is a measure of autocorrelation was calculated as 0.14 (Table 10). The expected value of I under randomness was the same as calculated for total farm area. The value of Var(I)

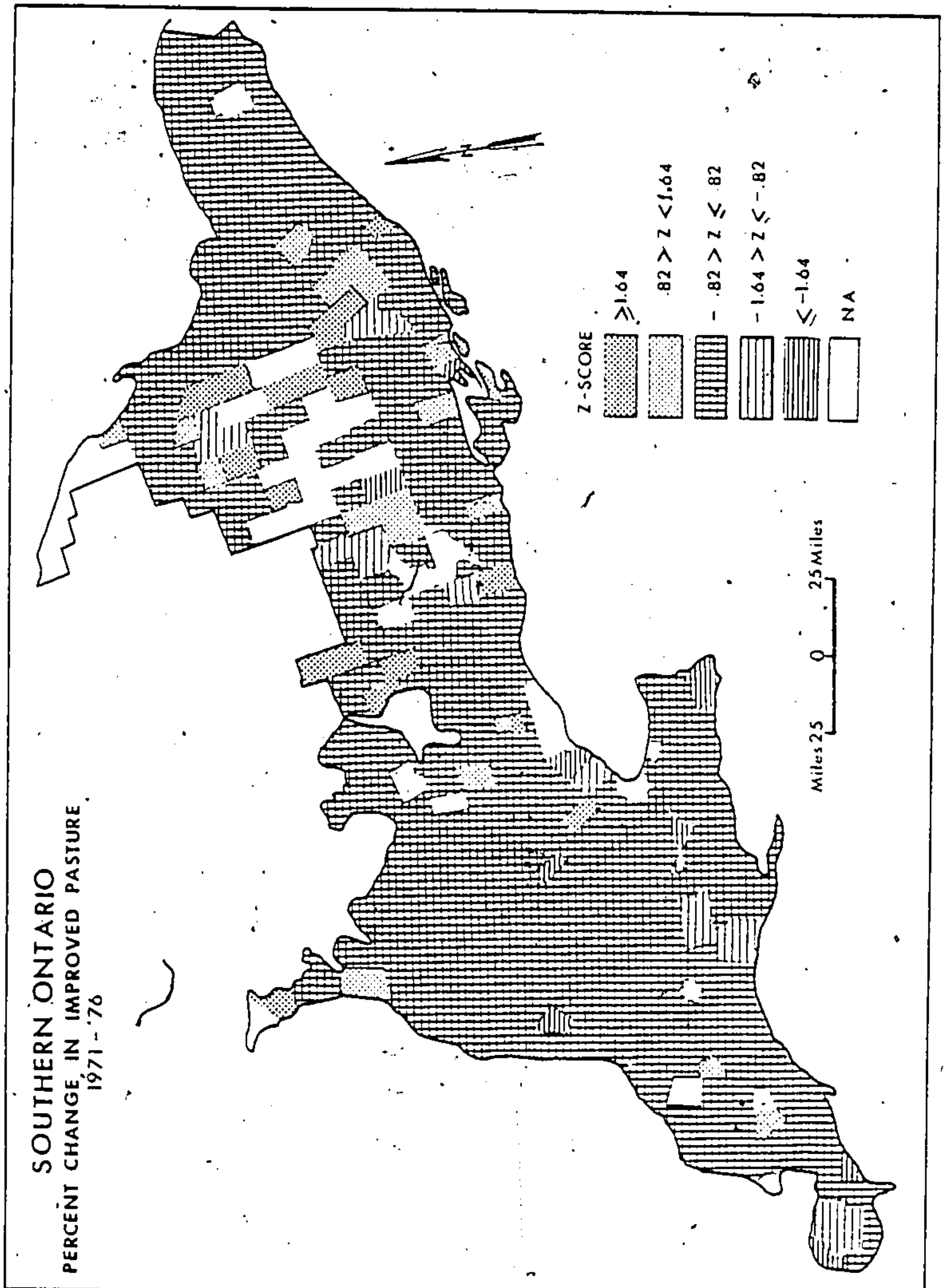
SOUTHERN ONTARIO
PERCENT CHANGE IN IMPROVED PASTURE
1971 - '76
Z-SCORE
≥1.64
.82 > Z < 1.64
- .82 > Z ≤ .82
- 1.64 > Z ≤ - .82
≤ -1.64
NA
N
Miles 25 0 25 Miles

Fig. 10

was also the same as calculated for total farm area. The standard normal deviate (Z_i) was calculated as 1.49, which fell below the Z-critical value of 1.96, the null hypothesis (H_o6) was therefore accepted.

A summary table of Moran's K-colour map analysis can be found in Table 10.

From the above analysis of spatial pattern of changes in total farm area, cropland and summer fallow and improved pasture, it can be summarized that all the townships of Southern Ontario had experienced a significant change in their agricultural land uses. Most of the townships had lost their total farm area, and improved pasture. Cropland and summer fallow had increased in the period 1971-1976. Such changes, on the other hand, reflected the temporal trend of change in agricultural land uses, as had been discussed earlier in the context of county level.

Spatially, changes in agricultural land uses varied greatly between Southwestern Ontario and Central and Eastern Ontario. Southwestern Ontario showed an increment or very low decrease of farmland in keeping with the good quality of soil found in the area. On the other hand, Central Ontario had experienced rapid urban expansion which led to the loss of farmland; and Eastern Ontario, which includes the Canadian Shield with poor soils had experienced a loss and abandonment of farmland. Such a spatial pattern of change at the

TABLE 10

SUMMARY OF MORAN'S K-COLOUR MAP ANALYSIS OF SPATIAL AUTOCORRELATION OF DEPENDENT VARIABLES

Study Variable	No. of Joins/ Links	I	r_a	(F(I))	P	$E(I)^2$	K	VAR(I)	Z-crit	Z_i
Total Farm Area	1043	0.44	0.15	-0.0083	0.0028	0.073	5136	0.073	1.96	1.66
Cropland & Summer Fallow	1043	0.24	0.08	-0.0083	0.0028	0.073	5136	0.073	1.96	0.92
Improved Pasture	1043	0.40	0.14	-0.0083	0.0028	0.073	5136	0.073	1.96	1.45

Source: Author.

township level substantiates the pattern of change observed at the county level.

Moran's K-colour map test indicated that there was no autocorrelation in the map pattern of total farm area, cropland and summer fallow and improved pasture. The pattern of change in those land uses was random, but the spatial configuration suggested their dependence on various influencing factors, such as urban expansion and soil quality.

CHAPTER FIVE

Some Factors Affecting Agricultural Land Use Changes: 1971-76

This chapter is devoted to the analysis of the relationships between the change in total farm area, cropland and summer fallow, and improved pasture and the growth of population, proportional distribution of good, medium, poor, and organic soil capability classes and the distance of each township from the nearest metropolitan cities with population of over 100,000. Before analysing the relationships, it would be useful to discuss the spatial patterns of population growth, the distribution of good, medium, poor and organic soil capability classes and the location of metropolitan cities in the study area.

1. Population, Soils and Cities:

(1) Growth of Population: 1951-1976 -

In the past 25 year period (1951-1976) the population of Southern Ontario had grown by 80 percent. In fact, the entire population increase may be attributed to the urban component (Fig. 11a). Rural population remained virtually unchanged, but within that category, the rural non-farm population also increased by 80 percent, indicating a decline in the rural farm population.

Spatially, at the township level, the growth of total population was not uniform. Most of the townships had experienced an increase, some exceeding more than 20 percent in the last 5 years (1971-1976).

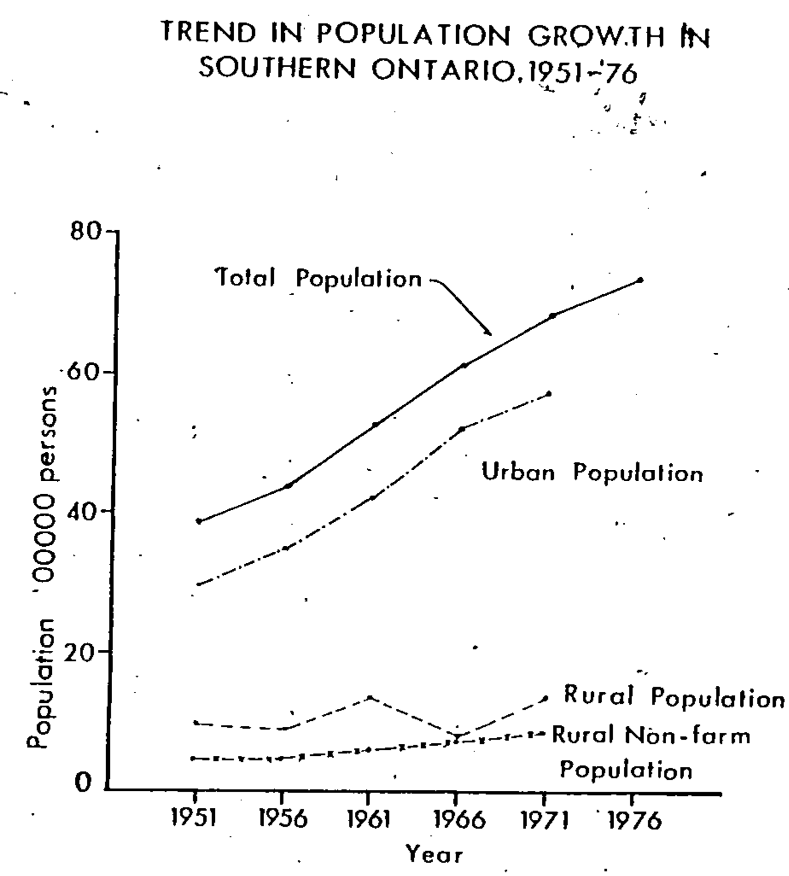

Fig.11a

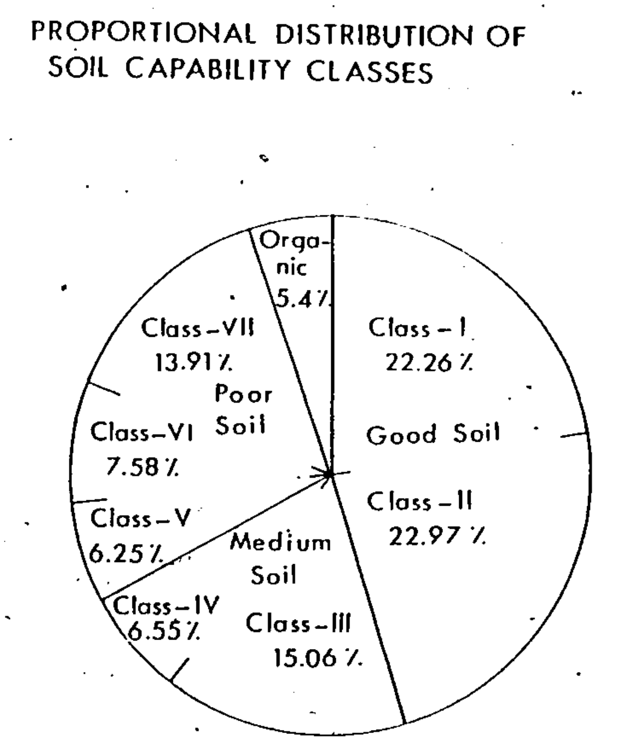

Fig.11b

A number of townships scattered throughout the study area had experienced a decline of less than 10 percent (Fig. 12). Only two townships in Renfrew county had experienced a more than 10 percent decline in total population.

Townships close to the main growth poles of metropolitan Toronto and Ottawa experienced very high percentage increase (more than 25 percent, Z-score 1.64). Similarly, townships of rapid recreational development surrounding Lake Simcoe, and the Kawartha Lakes, and in the Bruce county had experienced growth in excess of 25 percent.

Such a spatial pattern of population growth may have significant influence on the changes in agricultural lands in Southern Ontario.

(2) Proportional Distribution of Soil Capability Classes -

In the study area, the total soil resources for agriculture were differentiated into four classes: good, medium, poor and organic soils. These were derived from the ARDA soil capability classification for agriculture, where soil limitations for agriculture were considered to establish 7 capability classes and a separate category of organic soils (ARDA Report No. 2, 1970, p. 13). In this study, good soils included capability classes I and II of the ARDA soil classification (ARDA, Report No. 8). Most of the townships of South, Southwestern

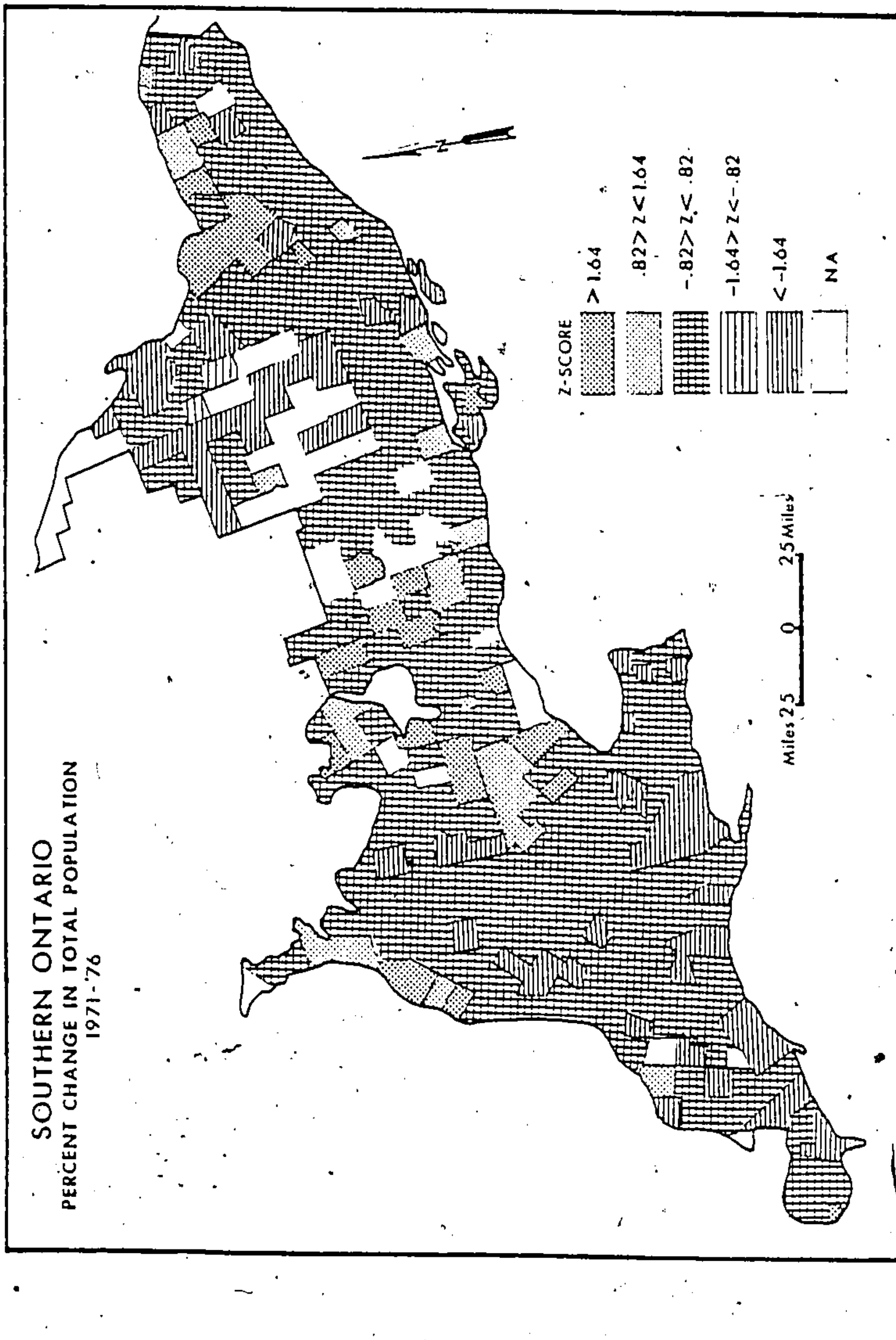
SOUTHERN ONTARIO
PERCENT CHANGE IN TOTAL POPULATION
1971-'76
Z-SCORE
> 1.64
.82 > Z < 1.64
-.82 > Z < .82
-1.64 > Z < -.82
< -1.64
NA
N
Miles 25 0 25 Miles

Fig.12

and Central Ontario have more than 40 percent of their area covered with good soils (Fig. 13). Only a few townships in Eastern Ontario and Prince Edward County also fit this category. Altogether, more than 45 percent of the total land of Southern Ontario has good soils. These soils are not only suitable for agriculture but also for urban construction, due to their well-drained properties and associated level terrain.

Medium soils include soil capability classes III and IV (ARDA, Report 8, 1975). These were found mostly in the townships of Eastern Ontario, although a few townships in the South and South-Western Ontario also had more than 40 percent of their land surface in medium soils (Fig. 13). Altogether Southern Ontario has 21.6 percent of its land area covered with medium soils.

Poor soils, in this study, include the remaining capability classes V, VI, and VII, whose limitations rule out arable farming. About 28 percent of the Southern Ontario townships had poor soils. Most of the poor soils are found in the Canadian Shield near Lake Simcoe, in the northern townships of Bruce and Grey counties and in Norfolk county (Fig. 13).

In the study area only 5.4 percent of the total area is found under organic soils, (Fig. 11b). Highest concentration (more than 10 percent) of this soil capability class was found in the Southeastern part of the Canadian Shield, and in Eastern Ontario (Fig. 13).

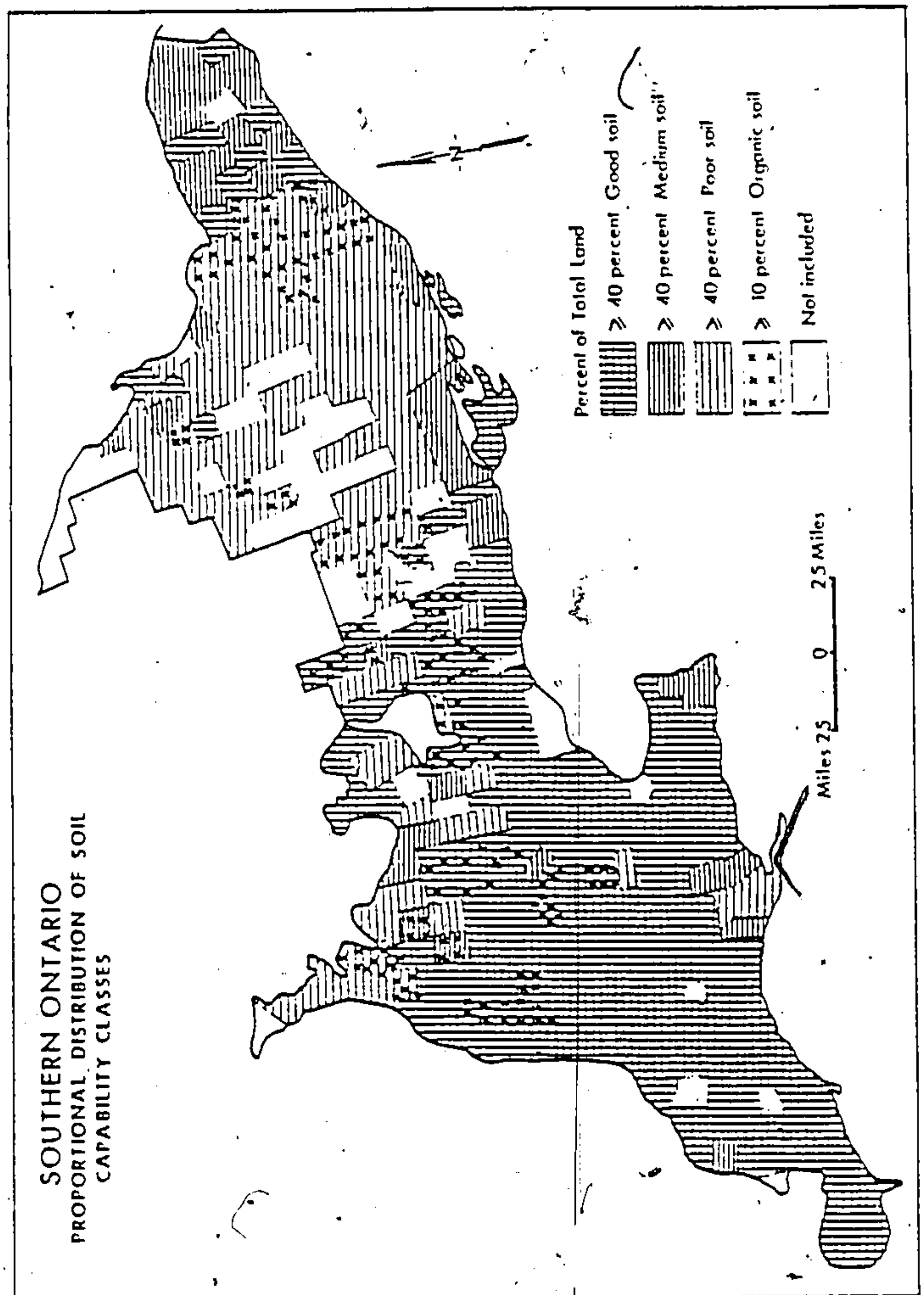
SOUTHERN ONTARIO
PROPORTIONAL DISTRIBUTION OF SOIL
CAPABILITY CLASSES
Percent of Total Land
≥ 40 percent Good soil
≥ 40 percent Medium soil
≥ 40 percent Poor soil
≥ 10 percent Organic soil
Not included
N
Miles 25 0 25 Miles

Fig. 13

A number of townships in Central Ontario along the Niagara escarpment and Bruce and Grey counties also have more than 10 percent of their land in organic soil.

Considering the proportional distribution of good, medium, poor and organic soil capability classes, it was found that most of the Southwestern Ontario and Central Lake Ontario plains were the areas of high concentration of good soils, whereas the Canadian Shield, and Eastern Ontario were the places of high concentration of medium and poor soils. Organic soil was more scattered, with highest concentrations in the Canadian Shield and Eastern Ontario. Figure 11b provides the data of proportional distribution of soil capability classes in Southern Ontario. It is expected that such patterns of distribution would exert some influence on the agricultural land use changes in the study area.

(3) <u>Distribution of Metropolitan Cities</u> -

In order to measure the influence of proximity to metropolitan centres on agricultural land use change, cities with population of over 100,000 persons were selected. This category, included Toronto (2,000,000), Ottawa (304,462), Hamilton (312,003), London (240,392), Windsor (196,526), Missisauga (250,017), St. Catherines (123,351), Kitchener (131,870), and Burlington (123,351), (Fig. 14).

The distance of each townships from its nearest city

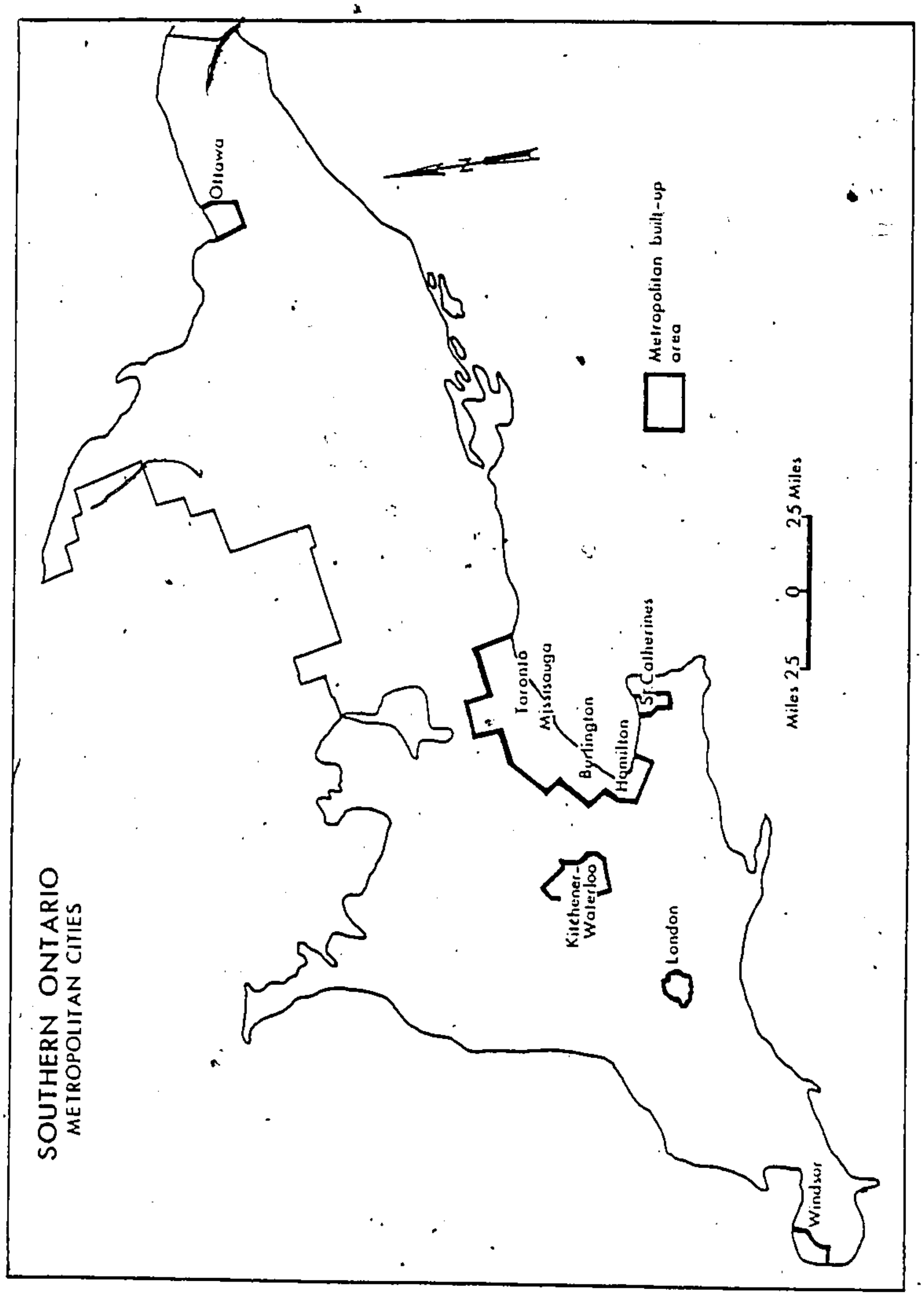
SOUTHERN ONTARIO
METROPOLITAN CITIES
Ottawa
N
Metropolitan built-up area
Miles 25 0 25 Miles
Toronto
Mississauga
Burlington
Hamilton
St.Catherines
Kitchener-Waterloo
London
Windsor

Fig.14

was measured in a straight line fashion from the city's built-up area to the township's centre.

II. Agricultural Land Use Changes:

The three independent variables described above were assumed to exert significant influence on the change of agricultural land uses in Southern Ontario. To analyse the relationships between changes in total farm area, cropland and summer fallow, and improved pasture, on the one hand, and the growth of population, proportional distribution of good, medium, poor and organic soil capabilities, and the distance factors, on the other, a stepwise multiple regression analysis was done for each of the dependent variables.

(1) Change in Total Farm Area -

Six independent variables were applied in a stepwise multiple regression to explain variation in the dependent variable, the percent change in total farm area (Table 11) as follows:

$$Y_c^{\frac{1}{2}} = 3.051-0.015X_2 +0.016X_1 -0.044X_3^{\frac{1}{2}} -0.019X_6^{\frac{1}{2}} -0.137X_4^{1/5} -0.024X_5^{\frac{1}{2}} . \qquad \text{(Eq. 1)}$$

The first independent variable in order of its significance (F-value), the percent of total land under good soils (X_2), explained 23.9 percent of the variation in the percent change of total farm area (Table 11). The second independent variable in order of significance, the percent change of total population (X_1), explained

TABLE 11

SUMMARY TABLE OF STEPWISE MULTIPLE REGRESSION OF THE DEPENDENT VARIABLE TOTAL FARM AREA

Step	Var.	Multiple R	R^2	R^2 Change	Partial Regression Coefficient	F-value
1	X_2	0.49	0.24	0.24 *	(X_2) -0.012	110.73
2	X_1	0.50	0.25	0.01 *	(X_2) -0.012 (X_1) 0.100	58.53
3	X_3	0.505	0.255	0.005 *	(X_2) -0.012 (X_1) 0.102 (X_3) -0.027	39.90
4	X_6	0.508	0.258	0.003 *	(X_2) -0.013 (X_1) 0.098 (X_3) -0.303 (X_6) 0.098	30.33
5	X_4	0.51	0.26	0.002 *	(X_2) -0.015 (X_1) 0.099 (X_3) -0.043 (X_6) -0.020 (X_4) -0.127	24.44
6	X_5	0.51	0.262	0.002 *	(X_2) -0.015 (X_1) 0.106 (X_3) -0.045 (X_6) -0.020 (X_4) -0.137 (X_5) -0.024	20.44

* Significant at 0.0001 level.

an additional 1.07 percent in the variation in the percent change of total farm area. The third independent variable, the percent of total land under medium soils (X_3), explained further 0.48 percent of the variation in the change of total farm area. The fourth independent variable entered, the distance of each township from its nearest metropolitan city with a population of over 100,000 (X_6), and explained a further 0.31 percent of the variation in the change of total farm area. The fifth independent variable entered, the percent of total land under poor soils (X_4), explained a further 0.16 percent of the variation in the percent change of total farm area. Finally, the last independent variable entered, the total land under organic soil (X_5), explained another 0.16 percent of the variation in the percent change of total farm area in Southern Ontario.

An F-test was applied to the six independent variables to determine their significance as factors influencing the percent change of total farm area in the townships of Southern Ontario. All the F-values for the six variables were not only above the F-critical value of 2.80 at 0.01 level, but also found significant at 0.0001 level (Table 11). Therefore, the null hypothesis that there was no significant relationship between the dependent and independent variables was rejected and the hypothesis (H_7) was accepted.

Since this regression model explained only 26 percent of the variation, it should be assumed that there are factors other than the six independent variables that affect the change in total farm area.

(11) <u>Change in Cropland and Summer Fallow</u> -

The same six independent variables were applied in a stepwise multiple regression to explain variations in the dependent variable, the percent change in cropland and summer fallow, as follows:

$$Y_c = -10055.574 + 100.653X_2 + 0.126X_1^{1/3} + 0.051X_6^{1/2} \quad \text{(Eq. 2)}$$

The first independent variable in order of its significance (F-value), total land under good soils (X_2), explained 1.2 percent of the variation in the percent change of cropland and summer fallow (Table 12). The second independent variable entered in order of significance (F-value), the percent change in total population (X_1), explained another 0.64 percent of the variation in the percent change of cropland and summer fallow. The third independent variable, the distance of each township from its nearest metropolitan city with a population of over 100,000 (X_6), explained a further 0.28 percent of the variation in the percent change of cropland and summer fallow. The fourth independent variable, the percent of total land under organic soil (X_5) explained a further 0.17 percent of

TABLE 12

SUMMARY TABLE OF STEPWISE MULTIPLE REGRESSION OF THE DEPENDENT VARIABLE CROPLAND AND SUMMER FALLOW

Step	Var	Multiple R	R^2	R^2 Change	Partial Regression Coefficient	F-value
1	X_2	0.11	0.0123	0.012 *	(X_2) 0.085	4.40
2	X_1	0.14	0.0187	0.0064 *	(X_2) 0.088 (X_1) 0.132	3.35
3	X_6	0.147	0.0215	0.0028 *	(X_2) 0.107 (X_1) 0.135 (X_6) 0.055	2.57
4	X_5	0.152	0.02324	0.0017 ≁	0.118 0.122 0.056 0.16	2.08
5	X_3	0.1525	0.02325	0.00001 ≁	0.1185 0.1221 0.0560 0.1598 1.0009	1.66
6	X_4	0.159	0.0254	0.0021 ≁	100.65 0.1260 0.051 100.67 100.53 100.53	1.51

* Significant at 0.05 level.

≁ Not Significant at 0.05 level.

the variation in the percent change of cropland and summer fallow. The fifth independent variable, the percent of total land under medium soils (X_3) explained a further 0.001 percent of the variation in the percent change of cropland and summer fallow. The last independent variable, the percent of total land under poor soils (X_4) explained further 0.21 percent in the variation of cropland and summer fallow.

An F-test, applied to the six independent variables, determined their significance as factors influencing the percent change of cropland and summer fallow in the townships of Southern Ontario. F-values calculated for variables X_1, X_2, and X_6 were found above the F-critical value of 2.10 at the 0.05 level of significance. But F-values calculated for variables X_3, X_4, and X_5 fell below the F-critical value of 2.10 at 0.05 level. Thus the null hypothesis, that there was no significant relationship between the dependent and independent variables could not be fully rejected and the hypothesis (H_8) was restated as follows:

H_8: Percent change in cropland and summer fallow is a function of (i) the percent change in total population, (ii) the percent of total land under good soil capability classes, and (iii) the distance of each township from its nearest metropolitan city with a population of over 100,000.

Since the present regression equation (Eq. 2) explained only 2.5 percent of the variation in the percent change of cropland and summer fallow, it should be assumed that factors even more powerful than the six independent variables treated above affect the change in cropland and summer fallow in the townships of Southern Ontario.

III. Change in Improved Pasture:

The same six independent variables were applied in a stepwise multiple regression analysis to explain the dependent variable, the percent change in improved pasture, as follows:

$$Y_c = -24320.918 + 243.232X_4^{1/2} + 0.189X_6^{\frac{1}{2}} + 0.154X_1^{1/3} + 242.731X_3^{\frac{1}{2}} + 242.970X_5^{\frac{1}{2}} + 242.820X_2 \quad \text{(Eq. 3).}$$

The first independent variable entered into the regression model in order of its significance (F-value), the percent of total land under poor soil (X_4), explained 13.5 percent of the variation in the percent change of improved pasture. The second independent variable, the distance of each township from its nearest metropolitan city with a population of over 100,000 (X_6), explained a further 1.2 percent of the variation in the percent change of improved pasture. The third independent variable, the percent change in total population (X_5) explained a further 0.30 percent of the variation in the percent change of improved pasture. The fourth independent variable, the percent of total land under

TABLE 13

SUMMARY TABLE OF STEPWISE MULTIPLE REGRESSION OF THE DEPENDENT VARIABLE

IMPROVED PASTURE

Step	Var	Multiple R	R^2	R^2 Change	Partial Regression Coefficient	F-value
1	X_4	0.3664	0.1342	0.1342 *	(X_4) 0.5049	54.59
2	X_6	0.3818	0.1457	0.0115 *	(X_4) 0.4304 (X_6) 0.1970	29.95
3	X_1	0.3856	0.1487	0.0030 *	(X_4) 0.4315 (X_6) 0.1971 (X_1) 0.1560	20.39
4	X_3	0.3876	0.1503	0.0016 *	(X_4) 0.4103 (X_6) 0.2043 (X_1) 0.1621 (X_3) -0.0979	15.43
5	X_5	0.3887	0.1511	0.0008 *	(X_4) 0.4062 (X_6) 0.2008 (X_1) 0.1453 (X_3) 0.0985 (X_5) 0.1887	12.53
6	X_2	0.3906	0.1526	0.0013 *	(X_4) 243.23 (X_6) 0.1893 (X_1) 0.1548 (X_3) 242.7313 (X_5) 242.97 (X_2) 242.82	10.64

* Significant at 0.001 level.

medium soils (X_3), explained another 0.16 percent of the variation in the percent change of improved pasture. The fifth independent variable, the percent of total land under organic soil (X_5), explained a further 0.08 percent of the variation in the percent change of improved pasture. The sixth independent variable, the percent of total land under good soils (X_2), explained another 0.13 percent of the variation in the percent change of improved pasture.

All the six independent variables were subjected to the F-test to determine their significance as independent variables affecting the percent change in improved pasture. F-value for each of the six independent variables were calculated (Table 13), and found above the F-critical value at 0.001 level of significance. The null hypothesis, that there was no significant relationship between the dependent and independent variables, was rejected, and the hypothesis (H_9) was accepted. Since the six independent variables explained only 15.3 percent of the variation, it should be assumed that other factors influence the percent change in improved pasture as well.

The analysis of the relationships between independent and dependent variables described above suggested that in Southern Ontario, changes in agricultural land uses were influenced by the chosen independent variables in different ways and to various degrees. In the analysis of change of total farm area, it was found that the distribution of good soils explained most of the variations accounted for by the six independent variables. Moreover, from the earlier analysis of the spatial pattern of change of total farm area, it was found that the townships with good soils experienced minimum decline in total farm area. From regression equation (1) it was found that population growth also has a significant influence; then medium soils have a significant relationship with the percent change in total farm area. Townships closest to the metropolitan city and with a high percentage of good soil had experienced a decrease of total farm area.

The analysis of change in cropland and summer fallow revealed that the selected independent variables could not explain as much of the variation. The distribution of good soils provided most of the explanation, with some significant explanation added by change in total population and the distance from metropolitan cities. Such relationships suggest that townships with high percentages of good soil and located close to the metropolitan city might show an increase of cropland and summer fallow which gives the idea of intensification of agriculture near the city.

Of the three land use change categories, the change in improved pasture was also explained effectively with the six independent variables. Changes in improved pasture were best explained by the distribution of poor soil, but further explanation was obtained from the distance from the metropolitan cities and the change in total population. Such relationship would suggest that townships with a high percentage of poor soil would experience high percentage increase of improved pasture. And townships closest to the metropolitan city would experience high percentage decrease of improved pasture. Such relationships have been uniquely reflected in the analysis of spatial pattern of change of improved pasture.

CHAPTER SIX

Conclusions:

In the present study, an attempt has been made to examine the temporal trend and spatial patterns of changes in agricultural land uses in Southern Ontario, and to measure the relationships between such changes and a number of physical, demographic and economic factors affecting them. Analysis of temporal trend in total farm area, cropland and summer fallow and improved pasture at the county level showed that during the 25 year period (1951-1976) total farm area and improved pasture in Southern Ontario had monotonically declined. On the other hand, cropland and summer fallow increased during this period. Such a long term trend in agricultural land uses at the county level have been reflected in the short-term period of analysis at the township level. In the recent 5 year period (1971-1976), 354 townships of Southern Ontario had experienced a loss of total farm area and improved pasture, but an increase in cropland and summer fallow.

Spatial patterns at the township level for the recent 5 year period (1971-1976) revealed small (±) percentage changes in agricultural land uses in the South, Southwestern and Central Ontario townships, and high (±) percentage changes in the Canadian Shield and Eastern Ontario townships.

Townships located closest to the metropolitan cities had greatest loss of farmland (total farm area and improved pasture) but increase of cropland and summer fallow. Townships with high percentage growth of total population have shown a decline of farmland. Townships with high percentage of good and medium soils had experienced minor changes in total farm area, cropland and summer fallow and improved pasture. On the other hand, townships with high percentage of poor soils had experienced high percentage decrease of total farm area, and cropland and summer fallow, but high percentage increase of improved pasture. There were no spatial autocorrelations existing in the map patterns. The spatial pattern of changes in agricultural land uses provided enough regularity to suggest certain relationships between selected independent variables and the dependent variables.

An analysis of the relationships between agricultural land use changes and the change in total population, proportional distribution of good, medium, poor and organic soils, and the distance from metropolitan cities, was successful. It demonstrated that changes in total farm area, cropland and summer fallow and improved pasture in the study area were significantly influenced by selected independent variables. Good soil capability, population growth, and proximity to metropolitan cities are all positively related and explain much of the decline in total farm area. On the other hand, good soil, population growth and proximity to metropolitan cities, influences the increment of cropland and summer fallow. Poor soil increases the improved pasture, but population growth and distance factor causes the decline of this land use.

The regression model explained only some of the variation in each category of land use change, suggesting that the six independent variables considered for this study were not the only factors influencing agricultural land use in Southern Ontario.

Direction for Further Research:

This study of agricultural land use change in Southern Ontario in relation to some factors affecting it has suggested a number of possible directions for future research. In general, the study of agricultural land use change in Southern Ontario is far from complete; there are many factors affecting agricultural land use, of which only six were examined in this study.

Physical factors such as the proportional distribution of soil capability classes have shown significant impact on the spatial pattern of agricultural land use change. To get a complete understanding of the influence of soil resources on agricultural land use change, it would be worthwhile to examine specific physical and chemical properties of soils and their relationships with the land use change, agroclimatic conditions and crop growing potentials.

Urban expansion has always been regarded as the key factor influencing agricultural land use change. In this study, the growth of total population and distance from metropolitan cities have been considered as indicators of urban expansion, but these variables explained only a small portion of the variation in the land use change.

In order to better grasp the influence of urban expansion on agricultural land use, a number of other independent variables should be collected and tested, such as the growth of urban population, the growth of rural non-farm population and the development of sub-divisions, industries, mining and transport networks.

Besides all these factors, socio-economic conditions such as change in land values, government policies, programmes pertaining to land use change may be examined to get better understanding of the dynamics of agricultural land use changes in Southern Ontario.

APPENDIX

SOUTHERN ONTARIO : NAME OF TOWNSHIPS

No.	Township	No.	Township
1.	Brantford	34.	Newcastle
2.	Burford	35.	Oshawa
3.	Dumfries	36.	Pickering
4.	Oakland	37.	Sengog
5.	Onondaga	38.	Uxbridge
6.	Paris	39.	Aldborough
7.	Albemanle	40.	Bayham
8.	Anabel	41.	Dorchester S.
9.	Arran	42.	Dunwich
10.	Brant	43.	Malahide
11.	Bruce	44.	Southwold
12.	Carrick	45.	Yarmouth
13.	Culross	46.	Anderdon
14.	Eastnor	47.	Colchester N.
15.	Elderslie	48.	Colchester S.
16.	Greenock	49.	Gosfield, N.
17.	Huron	50.	Gosfield, S.
18.	Kincardine	51.	Maidstone
19.	Kinloss	52.	Malden
20.	Lindsay	53.	Mersea
21.	St. Edmunds	54.	Pelee
22.	Amaranth	55.	Rochester
23.	Garafaxa E.	56.	Sandwich S.
24.	Luther, E.	57.	Sandwich W.
25.	Melanethon	58.	Tilbury, N.
26.	Mono	59.	Tilbury, W.
27.	Mulmur	60.	Bedford
28.	Matilda	61.	Clarendon & Miller
29.	Mountain	62.	Hinchinbrooke
30.	Williamsburg	63.	Howe Island
31.	Winchester	64.	Kinnebec
32.	Ajax	65.	Kingston
33.	Brock	66.	Loughborough

No.	Township	No.	Township
67.	Olden	101.	Nanticoke
68.	Oso	102.	Norfolk
69.	Palmerston N. & S. Canonto	103.	Burlington
		104.	Halton Falls
70.	Pittsburg	105.	Milton
71.	Portland	106.	Oakville
72.	Storrington	107.	Ancestor
73.	Charottenburgh	108.	Flamborough
74.	Kenyon	109.	Glanbrook
75.	Lancaster	110.	Stoney Creek
76.	Lochiel	111.	Bangour McClure & Wicklow
77.	Augusta		
78.	Edwardsburgh	112.	Carlow
79.	Gower S.	113.	Dunganon
80.	Oxford-on-Rideau	114.	Elzevir & Grimsthrope
81.	Wolford	115.	Hungerford
82.	Artemesia	116.	Huntington
83.	Bentinck	117.	Marmora Lake
84.	Collingwood	118.	Monteagle
85.	Derby	119.	Rawdon
86.	Egremont	120.	Sidney
87.	Euphrasia	121.	Thurlow
88.	Glenelg	122.	Wollaston
89.	Holland	123.	Indian Reserve
90.	Keppel	124.	Ashfield
91.	Normandy	125.	Colbourne
92.	Osprey	126.	Goderich
93.	Proton	127.	Grey
94.	St. Vincent	128.	Hay
95.	Sarawak	129.	Howick
96.	Sullivan	130.	Hullett
97.	Sydenham	131.	McKillop
98.	Delhi	132.	Morris
99.	Dunnville	133.	Stanley
100.	Haldimand	134.	Stephen

No.	Township
135.	Tuckersmith
136.	Turnberry
137.	Osborne
138.	Wawanosh E.
139.	Wawanosh W.
140.	Camden
141.	Chatham
142.	Dover
143.	Harwich
144.	Howard
145.	Orford
146.	Raleigh
147.	Romney
148.	Tilbury
149.	Bosanquet
150.	Dawn
152.	Enniskillen
153.	Euphemia
154.	Moore
155.	Plympton
156.	Sarnia
157.	Sombra
158.	Bathurst
159.	Beckwith
160.	Burgess N.
161.	Darling
162.	Drummond
163.	Elmsley, N.
164.	Lanark
165.	Lavant
166.	Montague
167.	Pakenham
168.	Ramsay
169.	Sherbrooke S.
170.	Bastard & Burgess S.

No.	Township
171.	Crossby N.
172.	Crossby S.
173.	Elizabethtown
174.	Elmsley S.
175.	F. of Escott
176.	Kitley
177.	F. of Leeds & Landsdowne
178.	R. of Leeds & Landsdowne
179.	F. of Younge
180.	R. of Younge & Escott
181.	Adolphustown
182.	Amherst
183.	Camden E.
184.	Denbigh
185.	Earnestown
186.	Fredericksburgh N.
187.	Kaladar & Angelesea & Effingham
188.	Richmond
189.	Sheffield
190.	Adelaide
191.	Biddulph
192.	Caradoc
193.	Delaware
194.	Dorchester N.
195.	Ekfrid
196.	Lobo
197.	London
198.	Megillivray
199.	Metcalfe
200.	Mosa
201.	Missouri W.
202.	Westminister
203.	Williams E.

No.	Township	No.	Township
204.	Williams W.	239.	Caledon
205.	Lincoln W.	240.	Mississauga
206.	Wainfleet	241.	Blanshard
207.	Niagara Falls	242.	Downie
208.	Pt. Colbourne	243.	Easthope, N.
209.	St. Catherines	244.	Easthope, S.
210.	Welland	245.	Ellice
211.	Fort Eric	246.	Elma
212.	Grimsby	247.	Fullarton
213.	Lincoln	248.	Hibbert
214.	Niagara-on-the Lake	249.	Logan
215.	Pelham	250.	Morington
216.	Thorold	251.	Wallace
217.	Alnwick	252.	Asphodel
218.	Brighton	253.	Belmont
219.	Gramahe	254.	Burleigh
220.	Haldimand	255.	Cavan
221.	Hamilton	256.	Chandos
222.	Hope	257.	Douro
223.	Murray	258.	Dummer
224.	Percy	259.	Harvey
225.	Cumberland	260.	Monaghan N.
226.	Gloucester	261.	Alfred
227.	Goulbourne	262.	Caledonia
228.	March	263.	Hawkesbury E.
229.	Nepean	264.	Hawkesbury W.
230.	Osgoode	265.	Longueuil
231.	Rideau	266.	Plantagenet N.
232.	West Carleton	267.	Plantagenet S.
233.	Blandford	268.	Ameliasburgh
234.	E. Zorra	269.	Athol
235.	Norwich	270.	Hallowell
236.	S.W. Oxford	271.	Hillier
237.	Zorra	272.	Marysburgh N.
238.	Brampton	273.	Marysburgh S.

No.	Townships	No.	Townships
274.	Sophiasburgh	309.	Oro
275.	Admastou	310.	Rama
276.	Algona N.	311.	Sunnidale
277.	Algona S.	312.	Tay
278.	Alice & Fraser	313.	Tecumseh
279.	Bagot	314.	Tiny
280.	Blithfield	315.	Cornwall
281.	Bromley	316.	Finch
282.	Brougham	317.	Osnabruck
283.	Brudenell Lydoch	318.	Bexley
284.	Grattan	319.	Carden
285.	Hagarty & Richards	320.	Dalton
286.	Mcnab	321.	Eldon
287.	Pembrooke	322.	Emily
288.	Petawawa	323.	Fenelou
289.	Radcliffe	324.	Laxton, Digby,
290.	Ross	325.	Manvers
291.	Sebastopol	326.	Mariposa
292.	Sherwood, Jones	327.	Ops
293.	Stafford	328.	Somerville
294.	WestMeath	329.	Dumfries N.
295.	Wilberforce	330.	Waterloo
296.	Cambridge	331.	Wellesley
297.	Clarence	332.	Wilmot
298.	Russell	333.	Woolwich
299.	Adjala	334.	Cambridge
300.	Essa	335.	Arthur
301.	Flos	336.	Erinmosa
302.	Gwillimbury	337.	Erin
303.	Innisfil	338.	Garafraxa W.
304.	Mara	339.	Guelph
305.	Matchedash	340.	Maryborough
306.	Medonte	341.	Minto
307.	Nottawasaga	342.	Nichol
308.	Orillia	343.	Peel

No.	Township	No.	Township
344.	Pilkington		
345.	Puslinch		
346.	Georgina		
347.	Gwillimbury E.		
348.	King		
349.	Aurora		
350.	Markham		
351.	Newmarket		
352.	Richmond		
353.	Vaughan		
354.	Witchurch		

BIBLIOGRAPHY

A.R.D.A.: Land Use Capability for Agriculture, Canada Land Inventory, A.R.D.A. Branch, p. 13, 1970.

________ Planning for Agriculture in Southern Ontario A.R.D.A. Report No. 7, 1972.

________ Acreage of Soil Capability Classes for Agriculture in Ontario, A.R.D.A. No. 8, pp. 9-53, 1975.

Austin, Morris E.: Land Resource Regions and Major Land Resources Areas of the United States (U.S. Dept. of Agriculture, Soil Conservation), 1965.

Burlowe, Raleigh: Land Resource Economics: The Economics of Real Property, Prentice-Hall, p. 86, 1972.

Bhatia, S.S.: "Dynamic Approach to the Analysis of Change: A case study of Cropland Use in Uttan Pradesh, India", Geographia Polonica, Vol. 19, pp. 226-247, 1970.

Bogue, Donald J.: Metropolitan Growth and Conversion of Land to Non-agricultural Uses, Oxford, Ohio, 1956.

Census of Canada: Agriculture, Ontario 1951, 1956, 1961, 1966, 1971 and 1976.

______________: Population, Ontario 1951, 1956, 1961, 1966, 1971 and 1976.

Chapman, L.J. and D.F. Putnam: Physiography of Southern Ontario, University of Toronto Press, pp. 272, 1966.

Crerar, A.D.: "The Loss of farmland in the Growth of Metropolitan Regions of Canada", Resource for Tomorrow, Supplementary Volume, Ottawa, Queen's Printer, 1961, p. 86.

Dunn, E.S. Jr.: The Location of Agricultural Production, Gainsville, University of Florida Press, pp. 9-24, 1954.

Ferguson, George A.: The Non-Parametric Trend Analysis, McGill University Press, Montreal, 1965.

Gaffney, Mason: "Containment Policies of Urban Sprawl", in Approaches to the Study of Urbanization, ed. by Richard L. Stauber, University of

Kansas, p. 11, 1964.

Garrison, W.L. and D.F. Marble: "The Spatial Structure of Agricultural Activities", Annals, Association of American Geographers, Vol. 47, pp. 137-144, 1957.

Gartler, L.O. and J. Hind-Smith: "The impact of Urban Growth on Agricultural Land: A Pilot Study" Resource for Tomorrow, Supplementary Volume, Ottawa, Queen's Printer, p. 175, 1961.

Girt, John L.: "The Spatial/Temporal Dynamics of Farmland Change in Southern Ontario: Trends and Projection", Studies in Rural Adjustment, Department of Geography, University of Guelph, Report No. 1, pp. 16-20, 1975.

Gregor, Howard F.: "Urban Pressure on California Land", Land Economics, Vol. 33, pp. 311-325, 1957.

Griffin, Paul F. and Ronald L. Chatham: "Urban Impact on Agriculture in Santa Clara County, California", Annals, Association of American Geographers, Vol. 48, pp. 195-208, 1958.

Grotewold, A.: "Von Thunen in Retrospect", Economic Geography, Vol. 35(4), pp. 346-355, 1959.

Hart, John F.: "Loss and Abandonment of Cleared Farmland in The Eastern United States", Annals, Association of American Geographers, Vol. 58, pp. 417-440, 1968.

Hoover, E.M.: Location Theory and the Shoe and Leather Industries, Cambridge, Mass., Harvard University Press, pp. 30-33, 1937.

Isard, W.: Location and Space Economy, New York, Willey, pp. 172-206 (195), 1956.

Krueger, Ralph R.: "Changing Land Use Pattern in the Niagara Fruit Belt", Transaction of Royal Canadian Institute, Vol. 32, pp. 39-140, 1959.

__________ "The Disappearing Niagara Fruit Belt" in Regional and Resource Planning in Canada. (edited by Krueger), Holt, Rinehart, pp. 134-149, 1970.

__________ "The Preservation of Agricultural Land in Canada" in Managing Canada's Renewable Resources, (ed.), Methuen, pp. 119, 1977.

Krueger, Ralph R.: "Urbanization of the Niagara Fruit Belt", The Canadian Geographer, Vol. 22(3), pp. 179-196, 1978.

Lösch, A.: The Economics of Location, translated by W.H. Woglom and W.F. Stolper, New Haven: Yale University Press, ch. 5, p. 41, 1954.

Martin R.G.: "Land Use Dynamics on the Toronto Urban Fringe", Environment Canada, Map Folio, No. 3, pp. 1-47, 1974.

Matthews, B.C.: "Soil Resource and Land Use Hazards in Southern Ontario, The Canadian Geographer, Vol. 2(8), pp. 55-62, 1956.

Ontario Institute of Agrologists: Foodland; Preservation on Starvation, A Statement on Land Use Policy, p. 14, 1975.

Pearson, Norman: "The Effect of Urbanization on Agricultural Land", The Centre for Resource Development, University of Guelph, Publication no. 65, p. 10, 1972.

Putnam, R.G.: "Changes in Rural Land Use Patterns on the Central Lake Ontario Plain", The Canadian Geographer, Vol. 6(2), pp. 60-68, 1962.

Ricardo, D.: The Principles of Political Economy and Taxation, (Everyman's Edition, London, Dent & Sons, Ltd.), p. 34, 1911.

Sinclair, Robert: "Von Thunen and Urban Sprawl", Annals, Association of American Geographer, Vol. 57, pp. 72-87, 1967.

Taylor, Peter J.: Quantitative Methods in Geography: An Introduction to Spatial Analysis, (Houghton Miffin Company, Boston).

Von Thünen, J.H.: The Isolated State, An English Translation, ed. P. Hall. Also in Michael Chisholm's Rural Settlement and Land Use (Aldine, 1970), pp. 20-23, 1826.

Ward, E.N.: Land Use Programs in Canada: Ontario, Environment, Canada, p. 74, 1977.

Zierman, D.M.: Rural to Urban Land Conversion, Fisheries and Environment Canada, Occasional Paper, no. 16, 1977.

Ziemetz, Kathryn A., et al: "Dynamics of Land Use Change in Fast Growth Areas", Economic Research Service, U.S. Dept. of Agriculture, Agricultural Economic Report no. 325, pp. 1-48, 1976.

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